Revisiting the Case for Flexible Exchange Rates

Proceedings of a conference
held by the Bank of Canada
November 2000

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Lawrence Schembri
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Introduction

Lawrence Schembri

The Bank of Canada's tenth annual research conference, held in November 2000, marked the fiftieth anniversary of Canada's adoption of a flexible exchange rate. For 43 of the past 51 years, Canada has had a floating rate, approximately 15 years longer than any other major industrialized country over this period.[1] Canada's successful post-war experience with a flexible rate, especially its most recent experience with a flexible rate and inflation targeting, has served as a useful example for other industrialized and emerging-market countries, including Mexico and Brazil.

The title of the conference, "Revisiting the Case for Flexible Exchange Rates," also recognized the seminal contribution of Professor Milton Friedman to exchange rate theory. His classic paper, "The Case for Flexible Exchange Rates," lucidly explains the critical arguments in favour of a flexible exchange rate and provides the intellectual foundation for Canada's flexible exchange rate regime.[2] Many of his arguments were re-examined in the papers presented at this conference, using recent developments in economic theory, as well as recent data and econometric techniques.

Friedman also made another more direct, but less well-known, contribution to Canadian exchange rate policy in a radio debate on this issue on

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[1] Canada returned to the Bretton Woods fixed exchange rate system on 2 May 1962, only to leave it for good on 31 May 1970. The other major industrialized countries joined Canada by abandoning the pegged-rate system in 1973. Canada's early experience with a flexible exchange rate, from 1950 to 1962, was often cited as an example of how well a floating rate could work. Not only was it cited by Friedman (1953), but it inspired many academic papers and several PhD theses, including those by current Federal Reserve presidents William Poole (St. Louis) and Robert McTeer (Dallas).

[2] Friedman's paper (1953) first appeared as a U.S. government memorandum in the autumn of 1950.

18 April 1948, with Bank of Canada Deputy Governor Donald Gordon and W.A. Mackintosh, a professor of economics at Queen's University. During the debate, Friedman argued that Canada's direct controls on imports should be replaced by a flexible exchange regime because "that is the most effective way of . . . making [import] goods more expensive to Canadians and your export goods cheaper to other people." . . . and "is it not better to let every individual decide for himself what items he wants to curtail in [the] face of higher prices than to have a government official do it in some . . . across-the-board, rough manner?" (Friedman, Gordon, and Mackintosh 1948, 6).

Less than 18 months after the radio debate, on 30 September 1950, Douglas Abbott, Canada's Minister of Finance, announced that "today the Government . . . cancelled the official rates of exchange. . . . Instead, rates of exchange will be determined by conditions of supply and demand for foreign currencies in Canada." Friedman could not have written it any better.[3]

Half a century later, in the aftermath of the currency crises of the 1990s and the formation of the European Economic and Monetary Union, the debate on the choice of exchange rate regime continues. The purpose of this conference was to contribute to this debate by re-examining the case for a flexible exchange rate (with some form of price-level or inflation target) against the alternative of a more permanently fixed regime, such as a common currency, in light of new theoretical and empirical developments. The papers presented investigated the experiences of a wide range of emerging-market economies and of several industrialized countries, including Canada.

The conference consisted of five sessions, a closing panel discussion, and the keynote address. Two papers were presented in each session: one by economists from the Bank of Canada, the other by outside academics. These were followed by comments from two designated discussants and questions from the floor. Michael Bordo of Rutgers University, John Helliwell of the University of British Columbia, and Richard Lipsey of Simon Fraser University were the distinguished members of the closing panel. Nobel Laureate Milton Friedman of the Hoover Institution gave the keynote address by video conference from Stanford University. Friedman and the panel members also took questions from the floor. This conference volume includes all of the papers, the addresses of the panel members and Friedman, and summaries of the question and answer periods. Highlights of the papers are outlined here, together with summaries of the panel discussion and the keynote address.[4]

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[3] Friedman claims in his autobiography that the radio discussion with Donald Gordon "played a major role" in Canada's adoption of a floating rate in 1950 (Friedman and Friedman 1998, 189).

Session 1:
Welfare Analysis

Much of the existing work comparing alternative exchange rate regimes is qualitative and lacks formal welfare analysis. The papers in this session attempted to fill this gap by employing dynamic general-equilibrium (DGE) models with explicit household welfare functions and optimizing behaviour by households and businesses.[5] To generate differences in the outcomes across the exchange rate regimes considered, both papers assumed some form of wage or price stickiness.

Tiff Macklem, **Patrick Osakwe**, **Hope Pioro**, and **Lawrence Schembri** use a calibrated three-sector DGE model of the Canadian economy (resources, manufacturing, and non-traded goods) to analyze the impact of stochastic shocks to the terms of trade under alternative exchange rate and monetary policy regimes. The two regimes considered are a flexible exchange rate with a price-level target, which is similar to Canada's current regime, and a permanently fixed exchange rate such as that under a currency union. The model explicitly incorporates the trade-off between the macroeconomic stability gains of a flexible exchange rate and the reduction in transactions costs offered by a fixed rate. Transactions costs in international trade are endogenously determined in the model as a function of the variability of the flexible rate. Fifty per cent of consumers are assumed to be credit-constrained, to reflect the fact that most agents cannot borrow in world capital markets to smooth the impact of exogenous shocks on their consumption. The results indicate that Canada would gain more by accommodating terms-of-trade shocks with a flexible exchange rate than it would by reducing transactions costs through the choice of a currency union. This difference arises because terms-of-trade shocks produce a variance in output that is almost 50 per cent greater under fixed than under flexible exchange rates. In addition, the authors find that, for fixed rates to dominate flexible rates, the transactions costs saved under a common currency would have to be 0.8 per cent of GDP or about four times greater than commonly estimated. They also examine the sensitivity of the results to increases in the degree of risk aversion and to increases in the probability of large shocks. In both cases, the welfare benefit of a flexible exchange rate would increase. They argue that their model is biased in favour of fixed rates, because it assumes that the shocks have the same effect on all workers, when in practice, the impact is very uneven. The results would, however, be less supportive of flexible rates if Canada's dependence on the production and export of primary commodities were to decline in the future.

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[4] These summaries draw on those prepared by John Helliwell for the closing panel.

[5] Moran (2000–2001) provides a recent survey of DGE models.

In his paper, **Michael Devereux** stresses the importance of the pricing behaviour of firms in the traded-goods sector on the choice of exchange rate regimes. In his model, the critical trade-off in the utility function is between the variability of inflation and output. In his monopolistically competitive price-setting framework, volatile inflation implies volatile markups and thus large departures from the optimal outcome. He argues that if firms in the traded-goods sector practice pricing to market and thus prevent the immediate pass-through of exchange rate movements into domestic prices, then a flexible exchange rate will likely be preferred over a fixed exchange rate system. A flexible regime will reduce the variability of output in the face of external shocks and will not significantly increase the volatility of inflation, if there is limited exchange rate pass-through to domestic prices. Devereux notes that exchange rate pass-through is likely to be more prevalent in emerging markets than in mature economies, making flexible rates a more attractive choice for mature economies than for emerging-market economies. His model incorporates a forward-looking Phillips curve, and he considers five alternative monetary policy rules, including a pegged exchange rate and two inflation-targeting rules with flexible exchange rates. With limited exchange rate pass-through, the flexible exchange rate rules produce higher welfare outcomes. Indeed, targeting the price of non-traded goods rather than the consumer price index basket is optimal.

Session 2:
The Role of the Exchange Rate in Adjustment and Integration

In choosing an exchange rate regime, it is important to consider the extent to which a regime best facilitates macroeconomic adjustment and economic integration. A flexible nominal exchange rate generally makes it easier for the real exchange rate to adjust in the face of exogenous shocks when prices or wages are sticky. Conversely, fixed exchange rates, especially in the form of a currency union, encourage economic integration in terms of trade and factor flows among countries by reducing the cost of international transactions.

Ramdane Djoudad, **Céline Gauthier**, and **Pierre St-Amant** address the issue of macroeconomic adjustment by extending the structural vector-autoregression (VAR) models of Dupasquier, Lalonde, and St-Amant (1997) and Clarida and Galí (1994) to incorporate commodity prices in the Canada-U.S. case. The motivation for including commodity prices in the model was the finding by Amano and van Norden (1993) that real commodity prices, primarily real non-energy commodity prices, are statistically significant explanations of movements in the Canadian real exchange rate. Using quarterly data for Canada and the United States from 1973 to 1999 to estimate their structural VAR model, the authors obtain several important results. First, the flexible Canadian nominal exchange rate facilitates macroeconomic adjustment by accelerating the realignment of the real exchange rate. Second, including the real prices of primary materials in the model does not change the key results of earlier studies, which find that most of the variation in real exchange rate and output is explained by real demand shocks and supply shocks. Third, monetary shocks do not play a large part in explaining movements in the real exchange rate.

Andrew Rose examines the impact of common currencies on economic integration. By drawing on his previous research and performing some new empirical work, he compares the economic integration of countries within currency unions to the integration of regions within a country and to integration among countries with different currencies. In general, he finds that the currency-union countries are more integrated than non-currency-union countries, but much less integrated than regions within a nation. Rose first considers the basic characteristics of currency-union members; they are typically small and poor countries and are more specialized than non-members. He then examines trade flows, real exchange rates, the synchronization of business cycles, and the sharing of consumption risk. Using a large panel-data set of over 150 countries at five-year intervals, Rose estimates an equation that includes a wide range of control variables and finds that trade is 340 per cent higher among members of a currency union than among non-members. Real exchange rate persistence is similar within and outside currency unions (i.e., the speed of real exchange rate adjustment is virtually the same), while real exchange rate volatility is lower within currency unions, while still being much greater than between cities within the same country. The business cycles of countries within currency unions are more synchronized than among countries not in currency unions but much less synchronized than those of regions within a single country. Finally, Rose asks whether consumption correlations are higher within currency unions; after controlling for synchronization of output, he finds no significant evidence of such an effect. Drawing on results from Frankel and Rose (2000), he concludes that the greater trade integration of currency unions is important because increased trade generates more output. As a caveat, Rose notes that it would require a leap of faith to apply these results, based on a sample of mainly small and poor currency-union members, to larger, more developed countries, such as Canada or members of the European Economic and Monetary Union.

Session 3: Exchange Rates, Currency Markets, and Trade Flows

Flexible exchange rates are often criticized as being excessively volatile; some observers believe that they are largely disconnected from macroeconomic fundamentals. This supposed disconnection is often used to justify central bank intervention in the foreign exchange market because, on its own, the market is unable to quickly return the exchange rate to its equilibrium level. Moreover, this exchange rate volatility is believed by many to have a significant deleterious impact on trade flows.

Ramdane Djoudad, **John Murray**, **Tracy Chan**, and **Jason Daw** investigate the significance of economic fundamentals in determining exchange rate movements in Canada as well as in Australia and New Zealand, two other major commodity-exporting countries. They begin by extending the Amano-van Norden (1993) error-correction model of the Canadian exchange rate to New Zealand and Australia. This model attempts to explain bilateral real exchange rates using non-energy commodity prices, energy prices, and interest rate differentials. The authors estimate these exchange rate models for all three countries (Australia, Canada, and New Zealand) and obtain similar results with good statistical fits. They then use these estimated exchange rate equations to approximate the behaviour of fundamentalist traders and apply regime-switching techniques to distinguish periods during which either chartists (technical traders) or fundamentalists dominate the foreign exchange market. A number of different technical trading rules are used to capture the behaviour of chartists. The authors find that on the more tranquil trading days (which represent roughly 70 per cent of all trading days), chartists dominate, while fundamentalists are more active during more turbulent times. The authors maintain that these results suggest that central bank intervention is not needed to help stabilize markets, since sharp increments in the exchange rates of the three countries are typically driven by fundamentalists pushing these currencies back to their equilibrium values. Finally, they argue that changes in monetary conditions caused by exchange rate movements should not necessarily be resisted by policy-makers, because such exchange rate movements usually reflect changes in the underlying fundamentals.

Philippe Bacchetta and **Eric van Wincoop** develop a theoretical general-equilibrium model with multiple sources of uncertainty to analyze the relationship between trade flows and fluctuations in the nominal exchange rate. In general, this relationship is ambiguous, but because it depends on the pricing behaviour of exporting firms, the authors first determine the optimal pricing strategy between producer currency pricing and local currency pricing (also known as pricing to market). They find that under reasonable parameter values, most firms would price to market, because it reduces risk by stabilizing sales volumes. They also show that once the pricing strategy is set, a fluctuating flexible exchange rate reduces trade only if exporting firms practice pricing to market, because exchange rate fluctuations will directly affect their revenue in their own currency. Whether or not trade is reduced in general depends on household preferences between consumption and leisure, monetary policy, and the extent of pricing to market. Their model predicts that as asset markets become more complete, firms will hedge their risks directly and move away from pricing-to-market behaviour. Thus the influence of the exchange rate regime on trade is likely to diminish.

Session 4:
Exchange Rate Uncertainty, Investment, and Productivity

Fluctuating nominal exchange rates may create uncertainty over the longer term, and this uncertainty may reduce investment because it worsens the risk-return trade-off and encourages investors to put off their investments. Lower investment levels also reduce labour productivity and, potentially, total or multifactor productivity, because new technology is often embedded in new capital. In addition, McCallum (1999), among others, has argued that a depreciating nominal exchange rate will hurt productivity, because it dulls the incentive to invest in productivity-enhancing improvements in physical, human, and research and development capital.[6] This argument, however, ignores the fact that most sustained movements in the nominal exchange rate are shifts in the underlying real exchange rate that would have occurred regardless of the exchange rate regime. The papers in this session examine the effect of exchange rate movements on investment and productivity in Canada.

Robert Lafrance and **David Tessler** investigate the effect of exchange rate variability on investment in Canada. They distinguish between the effects that may be caused by the potential misalignment of the exchange rate level and those that may result from the volatility of the exchange rate. The authors use Granger causality tests to investigate both types of effects and find that neither the misalignment of levels nor the volatility of the bilateral real exchange rate affects total domestic investment spending, investment in machinery and equipment, or foreign direct investment. They do find an effect from the level of the real exchange rate to the level of investment, but this disappears if the level of profits is controlled for by including it as a third variable in the test.

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[6] Lafrance and Schembri (1999–2000) examine the "lazy manufacturers" argument more closely and find numerous faults.

Richard Harris argues that the recent depreciation of the nominal exchange rate in Canada has had a negative impact on Canadian productivity. He notes that although most theory predicts that exchange rate depreciations should raise demand, factor utilization, measured productivity, and investment, the reverse has been true for Canada. Based in part on work by Michael Porter (1990), Harris maintains that real depreciations, by sheltering inefficient industries and raising input costs, lead to lower productivity. The interesting questions, in his view, relate to the nature of the channels or mechanisms through which productivity is reduced and the size of the effects. He identifies three mechanisms: relative factor costs, a gap in innovation, and a slowdown in creative destruction. The 1990s saw steady increases in the relative price of machinery and equipment to wages in Canada compared with the United States. Hence, over the 1990s, investment per hour worked grew substantially in the United States relative to Canada. The link between an innovation gap and the exchange rate is more difficult to discern. Harris argues that the nominal exchange rate depreciation increased the relative price of new technology and technology workers and encouraged firms to shift away from technology-producing activities. Finally, he maintains that the depreciation also allowed marginally profitable small firms to survive in Canada when firms with similar low profit margins were forced out of business in the United States. Using panel data on 14 OECD countries over the period 1970–97, Harris finds that recent exchange rate depreciations actually increase labour productivity, but that longer-term deviations from purchasing-power parity (as a measure of misalignment) worsen it, both by relatively small amounts.

Session 5:
Implications for Emerging-Market Economies

In the wake of the collapse of many pegged exchange rate regimes in the 1990s, there has been an important ongoing debate as to the appropriate exchange rate regime for emerging-market countries. A consensus seems to have emerged that ultimately these countries should choose either a flexible rate or some form of credibly fixed exchange rate regime. Two questions remain unanswered, however: first, which of the two extremes is appropriate, and second, how to get there.

Jeannine Bailliu, Robert Lafrance, and **Jean-François Perrault** examine the relationship between the exchange rate regime and the growth rate in emerging-market economies. They also develop a method for classifying exchange rate regimes based on the observed degree of exchange rate flexibility. Using multivariate regression, the authors test several hypotheses linking growth and exchange rate regimes for a sample of 25 developing countries, using data over the period 1973–98. They find that flexible exchange rate regimes are associated with higher growth for countries that are open to capital movements. This result also holds for countries with well-developed financial markets, but the positive effect of a flexible exchange rate on growth is not as strong. When other variables are held constant, changes in the exchange rate regime are also found to be associated with lower growth, probably because many of the changes that occurred in this sample of emerging-market countries involved the collapse of a fixed exchange rate.

Guillermo Calvo and **Carmen Reinhart**[7] emphasize the gap between announced and actual exchange rate regimes. After the collapse of pegged exchange rate regimes in emerging-market economies in the 1990s, many of the affected countries, such as Mexico and those in East Asia, announced the adoption of floating or managed floating exchange rate regimes. Although official data from the International Monetary Fund show a large movement towards more flexible exchange rate regimes (Fischer 2001), Calvo and Reinhart argue that these regime descriptions are misleading, since many of the countries described as floaters do not, in fact, allow their currencies to float because they fear the impact of exchange rate fluctuations on their economy. Analyzing a sample of more than 150 exchange rate arrangements, the authors find that many floaters have quite stable exchange rates and show considerable movements in reserves and interest rates because they are intervening to stabilize exchange rates. Their main argument in favour of a stable exchange rate is that large proportions of official and private debt are denominated in foreign currencies. Thus, a depreciating real exchange rate, for example, may actually be contractionary, not expansionary, because it may create severe financial problems for domestic creditors, primarily firms and government.

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[7] The Calvo and Reinhart paper, "Fear of Floating," does not appear in this volume. In its stead is "The Mirage of Floating Exchange Rates," by Carmen Reinhart.

Panel Discussion

Michael Bordo

Michael Bordo reviews the history of Canadian monetary regimes from 1820 to 2000. Over this period, Canada has experienced alternating fixed and floating regimes. Bordo's remarks focus on the determinants of these regimes. For most of the early part of the period, Canada was a follower. It went along with the prevailing international monetary arrangement, which Bordo characterizes as a gold convertibility contingency rule—a fixed convertibility rule between currency and gold with an escape clause that would allow convertibility to be suspended when warranted (e.g., World Wars I and II). He views the flexible exchange rate period 1950–62 as an escape-clause period rather than the beginning of a new era, and he sees the return to the fixed rate from 1962–70 as a return to the status quo. The new era began in the early 1970s, with the breakdown of the Bretton Woods system and the adoption of a fiat, rather than a commodity, standard with floating rates by most Western industrialized countries. Canada's adoption of explicit inflation targets in 1991, and their adoption by several other industrialized countries at the same time, can be interpreted as a new policy rule. Bordo calls it the domestic convertibility principle, which is similar to the convertibility principle that existed under the gold standard, because, with low inflation, the domestic currency is convertible into the domestic consumption basket at an almost fixed rate.

Richard Lipsey

Richard Lipsey organizes his remarks around five issues raised by the papers presented. First, he notes that to be taken seriously, critics of the current flexible exchange rate regime in Canada cannot simply list its faults but must fully articulate a feasible alternative regime. Second, useful criticisms of the current regime must compare its costs with those of an alternative regime. Third, the Bank of Canada's exchange rate equation may fit well, but it is not well understood. The negative sign on the energy price variable, as well as the absence of U.S. variables in a bilateral exchange rate equation, are puzzles that need to be explained. Fourth, although most of the evidence put forward at this conference seems to indicate that Canada is best served by a flexible exchange rate, Andrew Rose's results appear to be at odds with this. Nonetheless, Lipsey believes that neither Rose's findings, nor those of Calvo and Reinhart, apply to Canada, primarily because their samples of countries and time periods are not representative of the current economic situation in Canada. Finally, regarding productivity and technological change, the paper by Bailliu, Lafrance, and Perrault makes a useful contribution to the investigation of how exchange rate regimes affect economic growth, but the case is not closed. The paper by Richard Harris raises more questions than it answers, but should not be dismissed out of hand, because in a world of uncertainty, nominal variables such as the exchange rate regime could have an impact on real outcomes by affecting the path the economy takes.

John Helliwell

John Helliwell's comments are a series of remarks on the various papers. He notes that much of the research presented at the conference finds systematic advantages of flexible exchange rates over fixed. Indeed, the welfare difference for Canada is surprisingly large. The puzzling negative sign on the energy price variable in the Bank of Canada's exchange rate equation probably reflects the fact that the U.S. dollar is the currency preferred by major oil exporters for investment. Intervention in the Canadian foreign exchange market is often in the form of changes in monetary policy. Since these changes in interest rates are incorporated into the Bank's equation, it is misleading to argue that intervention is not needed, because the fundamentals, as specified by the equation, will drive the market back to equilibrium. One way of interpreting Andrew Rose's findings on the effect of a common currency on trade is to conclude that the right countries have joined currency unions, and not that this result is a prescription for other countries. In other words, the causality may run from large trade flows to a common currency, and not the other way around. Moreover, the Frankel and Rose results on the impact of currency unions on trade and then on growth are too large to be credible. Richard Harris's findings linking departures from purchasing-power parity to declines in productivity are misleading, because shifts in the terms of trade simultaneously reduce the value of output and, hence, productivity and cause flexible exchange rates to depart from purchasing-power parity. Finally, national markets for goods, services, labour, and capital are more segmented than economists typically believe—border effects are surprisingly large—yet this does not seem to significantly reduce welfare in small economies. Levels of GDP per capita across industrialized countries are not very different. Moreover, this segmentation of national markets, although not fully understood, strengthens the case for flexible rates.

Keynote Address: Milton Friedman

Milton Friedman began his remarks by noting that the last time he had extensive contact with the Bank of Canada was in 1948 in a radio debate with Deputy Governor Donald Gordon, and that this was probably the first time Donald Gordon had heard a serious defence of a flexible exchange rate.

He noted that Canada's initial experience with a flexible exchange rate from 1950 to 1960 was good one, in the sense that there was some fluctuation but no crises, and that speculation appeared to be stabilizing. Canada's return to a fixed rate in 1962 provided a very instructive experience, because the chain of policy mistakes began roughly two years earlier with the combination of bad monetary policy under Governor James Coyne and a market-determined floating exchange rate. After Coyne resigned, the Canadian government decided to force a competitive depreciation rather than correct monetary policy. In so doing, they created a speculative run against the Canadian dollar, which they finally stopped with a pegged exchange rate and massive intervention in the opposite direction. Canada floated again in 1970 to stem inflationary pressure coming from the United States, and over the next 30 years experienced easier monetary policy than the United States, which caused roughly half of the Canadian dollar's nominal depreciation. Nonetheless, because of its flexible exchange rate, Canada never experienced a crisis over this period like those that occurred in various countries in the 1990s. Such crises are always and everywhere caused by pegged exchange rates.

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Session 1:
Welfare Analysis

The Economic Consequences of Alternative Exchange Rate and Monetary Policy Regimes in Canada

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Tiff Macklem, Patrick Osakwe,
Hope Pioro, and Lawrence Schembri

Introduction

For the better part of the last half-century, Canada has been remarkable for its commitment to a flexible exchange rate. In 1950, Canada abandoned the carefully crafted, but fundamentally flawed Bretton Woods "fixed, but adjustable" exchange rate system for a flexible rate. In 1962, Canada rejoined the system, under unusual political circumstances, only to jettison it again for a flexible rate in 1970, for almost the same reasons as in 1950, namely the fear of imported U.S. inflation (see Powell 1999). On the basis of longevity alone, the Canadian flexible exchange rate regime has had a very successful run. Few exchange rate regimes can claim a tenure of almost 50 years.

Recently, several critics have argued that the curtain should come down on Canada's flexible rate regime, primarily because it is seen as a hindrance to further economic integration, chiefly with the United States, and to the transformation of the Canadian economy away from its reliance on commodity-based production and exports.[1] In contrast, supporters point to the impressive performance of the flexible rate during the recent 1997–98

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[1] Courchene and Harris (1999), Crow (1999), Grubel (1999), Laidler (1999), McCallum (1999), and Murray (1999) are recent contributions to the Canadian debate.

Asian crisis, when it facilitated the necessary real exchange rate adjustment to maintain high rates of employment and output growth.[2]

The purpose of this paper is to investigate the choice between the current exchange rate and monetary regime, a flexible exchange rate with an inflation target, and a permanently fixed rate under a monetary union, by analyzing the economic and welfare implications for Canada, using a well-specified dynamic general-equilibrium (DGE) model. This set of alternatives is motivated by the Canadian debate that has crystallized around the current regime versus a monetary union with a common currency, which would include Canada, the United States, and possibly Mexico and other Latin American countries. A North American monetary union (NAMU) is preferred to a currency board or dollarization, because it is viewed as being more politically palatable to Canadians, and because it would likely produce the largest economic gains in terms of reduced transactions costs.[3]

The Canadian debate is part of a broader worldwide re-examination of exchange rate regimes, prompted by two phenomena: the successful adoption of the formation of the European monetary union by 11 European countries in 1999 and the disruptive currency crises of the 1990s. This re-examination also focuses on a smaller set of alternative exchange rate regimes: a flexible regime versus some form of permanent fixed regime, whether it be a currency board, dollarization, or a common currency.[4]

Although the theoretical literature on optimum currency areas and alternative exchange rate regimes is extensive—with long lists of relevant criteria, advantages, and disadvantages—it provides only limited guidance for making a practical choice between alternative regimes. In particular, the existing research has significant weaknesses: (i) none of the current models adequately captures the crucial trade-off between macroeconomic flexibility and microeconomic efficiency in a rigorous and general-welfare-analytic framework (Krugman 1994); (ii) few of the models are empirical, and of those, most are calibrated to data at the most aggregate level; (iii) existing formal general-equilibrium (GE) models of optimum currency areas are either static or ignore international borrowing and lending driven by intertemporal consumption/savings and investment behaviour; (iv) most models do not allow agents to be heterogeneous in their ability to borrow.[5]

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[2] Despite a 7.5 per cent fall in the terms of trade from the fourth quarter of 1996 to the last quarter of 1998, GDP in Canada grew by 6.8 per cent over the same period, well over 3 per cent per annum.

[3] Panama and Ecuador are dollarized; Argentina and, to a lesser extent, Mexico, are considering it. However, the Argentinian proposal, as outlined by central bank President Pedro Pou (1999), moves in the direction of a monetary union, since it maintains that the U.S. authorities should return the seniorage and act as a lender of last resort.

[4] Intermediate managed regimes, in particular, garden-variety fixed exchange rates (de facto adjustable pegs) are no longer seen as viable. The currency crises of the 1990s clearly demonstrated that such regimes are unsustainable, because market participants understand that most countries are unable or unwilling to take the measures necessary to maintain such regimes under intense speculative pressure and, thus, the pressure becomes self-fulfilling. See Obstfeld and Rogoff (1995).

This paper overcomes these weaknesses by modelling the economic and welfare consequences of a flexible exchange rate and common currency using a calibrated stochastic DGE model for Canada with risk-averse and credit-constrained agents. At the model's core is the trade-off between the microeconomic efficiency gains (i.e., the reduction in transactions costs) resulting from a common currency versus the gains in macroeconomic stabilization provided by a flexible rate adjusting to asymmetric exogenous shocks.

A flexible exchange rate generates transactions costs because it, like any other forward-looking asset price, is inherently volatile; in particular, it will respond to the release of new (and therefore unexpected) information and to shifts in the expectations of investors about the future path of the underlying fundamentals.[6] This volatility raises two questions: is it excessive? and, more importantly, does it entail significant real costs? There has been much debate on both of these questions, but with rare consensus. In terms of the first question, models based on macroeconomic fundamentals cannot explain short- to medium-term exchange rate movements, but this may reflect the inadequacy of the models themselves.[7]

On the second question, certain types of transactions costs are well known—foreign exchange hedging and conversion costs, for example. Nonetheless, there is no compelling evidence that these exchange-rate-related transactions costs significantly impede international trade or investment flows. This lack of evidence was consistent with the beliefs of most economists, who felt that it was relatively inexpensive to manage exchange rate volatility. Recent evidence on the unexpectedly large impact of borders and common currencies on trade by two of the participants in this conference, John Helliwell and Andrew Rose, has challenged this long-held

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[5] For example, the Ricci (1997) model is static, and Beine and Docquier (1998) assume that agents do not save. Lafrance and St-Amant (1999) survey the recent literature.

[6] Others have argued that exchange rates are not only subject to short-term volatility, but also to longer-term misalignment because of the existence of speculative bubbles and rational-noise traders. While these arguments may be appealing, there is limited empirical evidence to support them. See Murray, van Norden, and Vigfusson (1996).

[7] Flood and Rose (1995), for example, find little evidence that exchange rate volatility is related to the volatility of the underlying macroeconomic fundamentals.

belief.[8] There are also other potential real costs associated with exchange rate volatility: segmented capital markets, higher interest rate risk premiums, and efficiency losses due to incomparable prices.

A common currency, however, produces more variable output and employment in the face of external real shocks than does a flexible exchange rate, because nominal wages and, to a lesser extent, prices, are sticky. In contrast, a flexible rate responds when these shocks hit the economy, accelerating the adjustment process. For example, sharp increases in the U.S. demand for Canadian exports during the Korean and Vietnam wars brought about the exchange rate regime changes in 1950 and 1970; in both cases, the flexible rates appreciated as expected, thus moderating Canadian demand and price pressures. In addition, the dramatic commodity price movements in 1972–74 (upwards) and in 1997–98 (downwards) caused the flexible rate to appreciate and depreciate respectively, thereby facilitating macroeconomic adjustment.

In the case of commodity price shocks, the crucial point is that they have asymmetric impact on the Canadian and U.S. economies because of their different industrial structures.[9] In particular, Canada's exports are more heavily based on commodities; they represent approximately 9.5 per cent of GDP and 28 per cent of exports, as opposed to 1.2 per cent of GDP and 10 per cent of exports for the United States.[10] Thus, the flexible bilateral exchange rate helps the Canadian economy adjust to the differential impact of such shocks. This is important because of the lack of labour mobility between the two countries and the absence of supranational fiscal transfers.

To evaluate the relative economic implications of the current flexible regime and inflation (price-level) targeting versus a common currency, we adapt the small open economy DGE model of Macklem (1993b).[11] The primary types of shocks analyzed in the model are terms-of-trade shocks, because of the relative importance of exogenously determined commodity prices to the Canadian economy. The Macklem model is a useful starting point, because it explicitly addresses the structural features of the Canadian economy, which has a well-developed domestic manufacturing sector and an export-oriented resource sector.[12] However, we modify and extend the original Macklem model in several important ways: (i) we simulate the model with stochastic shocks (drawn from normal and extreme-value distributions) rather than deterministic shocks; (ii) the logarithmic utility function used in the Macklem model is generalized to a constant-relative-risk-aversion (CRRA) utility function that allows the degree of risk aversion to be varied; (iii) the model incorporates endogenous transactions costs due to exchange rate variability; (iv) some agents are assumed to be credit-constrained; (v) welfare-based comparisons of the different exchange rate regimes are performed.[13]

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[8] Côté (1994) provides a survey on the impact of exchange rate volatility on trade. McCallum (1995) and Helliwell (1996) find that the Canada-U.S. border is a significant barrier to trade. Engel and Rogers (1996) discover that it hinders price arbitrage, and Rose (2000) estimates that common currencies have a large and significant impact on trade flows.

[9] Dupasquier, Lalonde, and St-Amant (1997) find evidence that the external shocks hitting the two economies are asymmetric.

[10] These commodity export data are from the Organisation for Economic Co-operation and Development (OECD) two-digit trade data on primary exports. These data are intended to be comparable across countries. Statistics Canada data, which include commodity-based manufactured products, such as lumber and metals, would increase these ratios for Canada. That is, using these data, commodity-based exports are 11 per cent of GDP and 35 per cent of total exports.

[11] Note that in the context of the model, inflation and price-level targeting are the same. In practice, they have different implications for monetary policy.

The main findings of the paper are that employment, output, and, to a lesser extent, consumption, are much more volatile under a fixed exchange rate when the economy is subject to terms-of-trade shocks. Because agents are risk-averse, this volatility has significant welfare costs. Moreover, transactions costs would have to be relatively high and agents almost risk-neutral for the welfare advantage of a flexible exchange rate to disappear.

Section 1 of this paper presents the benchmark model with nominal-wage rigidity and no trade-related costs. In section 2, we analyze results of the benchmark model, establish the case for a flexible exchange rate regime, and examine the economic consequences of introducing exchange-rate-related transactions costs, credit constraints, and extreme-value shocks, for the choice of exchange rate regimes in the model. Section 3 deals with the welfare effects of alternative regimes. The paper concludes with a summary of the interesting results and suggestions for future research.

1 The Benchmark Model

Consider a continuous-time model of a small open economy with three production sectors: non-tradables (good 0), resources (good 1), and manufactured goods (good 2). We assume that the country is a net exporter of resources, a net importer of manufactured goods, and that it is inhabited by three sets of agents: consumers, firms, and a government. Population is assumed to grow at the exogenous rate, υ, and labour-augmenting technical change occurs at the rate ϕ. The rest of the world is assumed to grow at the same rate as the small country; consequently, the small country remains so in the sense that it takes the world real interest rate and the world prices of tradable goods as given. The prices of non-tradables, p_0, and resources, p_1, as well as the world real interest rate, r, are defined in terms of the manufactured good (the numeraire). Since the small country exports resources and imports manufactured goods, p_1 is also the terms of trade.

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[12] Unlike the European Economic and Monetary Union (EMU) model of Beine and Docquier (1998), we do not incorporate supranational fiscal transfers or intercountry labour flows, because they are less likely to occur in the NAMU than in the EMU.

[13] To perform welfare comparisons under different exchange rate regimes, we simplified the fiscal side of the original Macklem model to preclude tax- or expenditure-based shifts in purchasing power across generations. Thus, for the purpose of analyzing the welfare effect of different exchange rate regimes, we can focus on a single generation because the impact would be symmetric.

1.1 Consumption

The economy is inhabited by a growing population of overlapping generations (OLGs) of consumers. The consumer maximizes the expected discounted value of utility over his or her lifetime. Consumer behaviour is modelled following the Blanchard-Weil uncertain-lifetimes approach, in which consumers face a constant probability of death, π, throughout their lives.[14] Relative to the standard infinitely-lived representative-agent model, the impact of introducing uncertain lifetimes is to increase the rate at which the consumer discounts the future above the pure rate of time preference, ρ. Labour is supplied inelastically. In each period, consumers receive an endowment of one unit of time from which they take Λ units in leisure and work the remaining $1 - \Lambda$ units.

Aggregate consumption is obtained by integrating over generations of consumers. To induce stationarity, aggregate variables are deflated by the labour force, which is measured in efficiency units. Assuming a momentary utility function of the CRRA class with risk-aversion parameter, φ, optimal consumption plans give rise to the following equations:[15]

$$c = \frac{1}{\Delta}[a + h], \tag{1}$$

$$\Delta = \int_t^{\infty} \exp -\left[\left(1 - \frac{1}{\varphi}\right)r + \pi + \frac{\rho}{\varphi}\right](s - t)\left[\frac{p_0(s)}{p_0(t)}\right]^{\frac{\theta_0(\varphi - 1)}{\varphi}} ds, \tag{2}$$

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[14] For a more detailed description of the uncertain-lifetimes model of consumption behaviour, see Blanchard (1985) and Weil (1989).

[15] Time subscripts are suppressed except in cases where confusion could result. A complete list of the variable and parameter definitions is provided in Appendix 1.

$$h = \int_{t}^{\infty}\{(1-\Lambda)w(s)-\tau(s)\}\exp[-(r+\pi-\phi)(s-t)]ds, \tag{3}$$

$$a = \sum_{i=0}^{2}(q_{i0}k_{i0}+q_{i2}k_{i2})+b+f+p_L L, \tag{4}$$

$$c_0 = \theta_0 c/p_0, \tag{5}$$

$$c_1 = \theta_1 c/p_1, \tag{6}$$

$$c_2 = (1-\theta_0-\theta_1)c. \tag{7}$$

In equation (1), total consumption, *c*, is proportional to total wealth, which is the sum of human wealth, *h*, and non-human wealth, *a*. The inverse of the marginal propensity to consume, Δ, is given by equation (2). Human wealth, given in equation (3), is the present value of wage income $(1-\Lambda)w$ net of consumer taxes, τ. In equation (4), non-human wealth is the value of capital in firms (the *qk*'s), plus government debt, *b*, foreign assets, *f*, and the value of land, $p_L L$. Land, *L*, is in fixed total supply and has value, p_L, because land is used in the production of resources. In equations (5) to (7), consumption expenditures on non-tradables, c_0, resources, c_1, and manufactured goods, c_2, are proportional to total consumption expenditures where the θ's are the share weights in the CRRA utility function.

1.2 Production

There are three types of firms: non-tradables producers, resource producers, and manufacturers. Each firm maximizes the value of the firm. This problem is dynamic because capital is costly to adjust. Firms are assumed to discount the future at the world real interest rate, *r*, plus a premium, ψ.[16] Firms producing non-tradables and manufactured goods are modelled symmetrically, although their behaviour can differ substantially because of different factor intensities. Resource production is modelled slightly differently to capture the importance of natural-resource endowments for the production of resource-based goods.

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[16] The risk premium is a transactions cost associated with obtaining investment funds.

1.2.1 Non-tradable and manufactured goods

Producers of non-tradables and manufactured goods combine inputs of capital, labour, and resources to produce output, using a constant returns to scale (CRS) Cobb-Douglas technology. There are two types of capital: structures that are formed from the non-tradable good and machinery that is formed from the manufactured good. As in the literature, investment in both types of capital is subject to quadratic installation costs (following the *q* and the cost-of-adjustment approach).

The behaviour of firms producing non-tradables and manufactured goods is described by the following equations. Again, quantity variables that exhibit trend growth are measured per efficiency unit of labour to induce stationarity.

$$y_j = \Phi_j k_j^{\alpha_j} z_j^{\beta_j} n_j^{1-\alpha_j-\beta_j}, \qquad (8)$$

$$k_j = k_{j0}^{\sigma_j} k_{j2}^{1-\sigma_j}, \qquad (9)$$

$$\dot{k}_{jm} = i_{jm} - (\delta_{jm} + \upsilon + \phi) k_{jm}, \qquad (10)$$

$$i_{j0} = \left(\frac{q_{j0} - p_0}{\eta_{j0} p_j} + (\delta_{j0} + \upsilon + \phi)\right) k_{j0}, \qquad (11)$$

$$i_{j2} = \left(\frac{q_{j2} - 1}{\eta_{j2} p_j} + (\delta_{j2} + \upsilon + \phi)\right) k_{j2}, \qquad (12)$$

$$q_{j0} = \int_t^{\infty} \left(\frac{\sigma_j \alpha_j p_j(s) y_j(s)}{k_{j0}(s)} + \frac{(q_{j0}(s) - p_0(s))^2}{2\eta_{j0} p_j(s)} - p_0(s)(\delta_{j0} + \upsilon + \phi)\right)$$

$$\exp[-(r + \psi - \upsilon - \phi)(s - t)] ds, \qquad (13)$$

$$q_{j2} = \int_t^{\infty} \left(\frac{(1 - \sigma_j)\alpha_j p_j(s) y_j(s)}{k_{j2}(s)} + \frac{(q_{j2}(s) - 1)^2}{2\eta_{j2} p_j(s)} - (\delta_{j2} + \upsilon + \phi)\right)$$

$$\exp[-(r + \psi - \upsilon - \phi)(s - t)] ds, \qquad (14)$$

$$\gamma_{jm} = \frac{\eta_{jm}}{2}\left(\frac{i_{jm}}{k_{jm}} - (\delta_{jm} + \upsilon + \phi)\right)^2 k_{jm}, \qquad (15)$$

$$z_j = \beta_j p_j y_j / p_1, \tag{16}$$

$$n_j(t) = (1 - \alpha_j - \beta_j) p_j(t) y_j(t) / w_j(t). \tag{17}$$

Output in the non-tradables sector, $j = 0$, and the manufacturing sector, $j = 2$, is produced using inputs of an index of the capital stock, k, resources, z, and labour, n, according to equation (8). The index of capital is a CRS Cobb-Douglas function of capital formed from non-tradables, k_{j0}, and capital formed from manufactured goods, k_{j2}. Capital of both types, $m = 0,2$, depreciates at rate δ_{jm} according to equation (10). From equations (11) and (12), investment in sector j in type m capital i_{jm}, depends on the difference between the market value of type m capital in sector j (q_{jm}) and the spot price of new type m capital. If this difference is positive, investment is above its steady-state level, while if it is negative, investment is below its steady-state level. The value of type m capital in place in sector j is given by the asset-pricing relationships (13) and (14). The value of capital is equal to the present value of the current and future marginal products of capital where this marginal product is the sum of the marginal product of capital in production and the marginal reduction in the cost of installing a given flow of investment. As specified in equation (15), adjustment costs, γ, are assumed to be an increasing function of investment relative to the existing capital stock and are only incurred when investment is above or below its steady state. From equations (16) and (17), resource inputs are used until their marginal product equals their relative price, and labour is hired until its marginal product equals the real wage.

1.2.2 Resource sector

Firms in the resource sector have the same objective as those in the non-tradables and manufacturing sectors. However, as indicated earlier, they differ in one significant respect. In addition to labour and capital, resource production requires the input of a fixed factor called land. This fixed factor is best interpreted broadly to include natural-resource endowments such as forests, minerals, fish, and hydroelectric potential, as well as arable land in the case of agriculture. Land is in fixed total supply, but its productivity is assumed to increase over time as a result of exogenous technical progress associated with improved methods of finding and extracting natural resources. To obtain a balanced growth path in the model, it is further assumed that the productivity of land grows at the rate of labour-augmenting technical progress in production plus the rate of population growth. This assumption is motivated largely by the practical benefits of obtaining a balanced growth path for the solution of the model, but may be justified by the fact that, over the horizon of interest in this paper, the resource sector can be reasonably expected to have the same average growth rate as the other sectors. With the introduction of land in this form, the production function for resources expressed per efficiency units of labour is:

$$y_1 = \Phi_1 k_1^{\alpha_1} L^{\omega} n_1^{1-\alpha_1-\omega}. \tag{18}$$

The production function is CRS in the three inputs, but in terms of the variable factors—capital and labour—production exhibits decreasing returns to scale. It is worth noting that the presence of a fixed factor in resource production plays an important role in determining the equilibrium structure of this economy. In the absence of a fixed factor in the resource sector, the small economy would specialize in the production of a single tradable good—either resources or manufactured goods (as in Macklem 1993a). The presence of land limits the ability of the resource sector to expand and permits both resource production and manufacturing to coexist in equilibrium for a range of parameter values.

In other respects, resource firms are the same as non-tradables producers and manufacturers. The behaviour of resource firms is therefore also described by equations (9) to (15), with $j = 1$. The labour-demand equation is slightly different, reflecting the presence of land in the production function:

$$n_1(t) = (1-\alpha_1-\omega)p_1(t)y_1(t)/w_1(t). \tag{19}$$

1.3 Government

The government is assumed to have exogenously fixed total spending requirements, g. Expenditures are allocated to non-tradables, g_0, resources, g_1, and manufactured goods, g_2, according to the decision rules:

$$g_0 = \xi_0 g/p_0, \tag{20}$$

$$g_1 = \xi_1 g/p_1, \tag{21}$$

$$g_2 = (1-\xi_0-\xi_1)g, \tag{22}$$

where the ξs are fixed-share weights. These decision rules are not derived from a theory of government, but they are symmetric with consumer behaviour and the share weights are easily calibrated to the data.

Expenditures are financed by imposing taxes, τ, and issuing government debt, b. The government is assumed to target a fixed level of debt in efficiency units (so the debt-to-GDP ratio remains constant along the steady-state growth path). Taxes are set to cover the net service cost on the outstanding stock of government debt and government spending on goods and services:

$$\tau = (r - \upsilon - \phi)b + g. \tag{23}$$

1.4 Market-clearing conditions

Market clearing requires that demand equals supply in goods, labour, and asset markets:

$$\tilde{y}_0 = c_0 + i_{00} + i_{10} + i_{20} + \gamma_{00} + \gamma_{02} + g_0, \tag{24}$$

$$\tilde{y}_1 = c_1 + z_0 + z_2 + \gamma_{10} + \gamma_{12} + g_1 + x_1, \tag{25}$$

$$\tilde{y}_2 = c_2 + i_{02} + i_{12} + i_{22} + \gamma_{20} + \gamma_{22} + g_2 + x_2, \tag{26}$$

$$1 - \Lambda = n_0 + n_1 + n_2, \tag{27}$$

$$w_0(t) = w_1(t) = w_2(t), \tag{28}$$

$$\dot{p}_L = (r + \psi - \upsilon - \phi)p_L - \omega p_1 y_1 / L, \tag{29}$$

$$ca \equiv \dot{f} = (r - \upsilon - \phi)f + x, \tag{30}$$

$$x = p_1 x_1 + x_2. \tag{31}$$

Equations (24) to (26) set demand equal to supply in the goods markets for non-tradables, resources, and manufactured goods, where $\tilde{y}_j$ is gross output net of the transactions costs associated with financing investment.[17] Since non-tradables are neither imported nor exported, equation (24) is the familiar closed-economy equilibrium condition with the addition of adjustment costs (the γs).[18] Equilibrium in the labour market requires that labour is fully employed and that the real wage is equal in all three sectors. The demand for land equals its fixed supply when the price of land equals the expected present discounted value of the current and future marginal products of land. In the steady state, the relative price of land grows at the rate at which land becomes more productive; p_L in equation (29) is the relative price of land, adjusted for productivity growth. The model is closed by equations (30) and (31), which describe the evolution of foreign assets and define the trade balance, x.

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[17] In terms of the algebra of the model, $\tilde{y}_j = y_j - \psi(q_{j0}k_{j0} + q_{j2}k_{j2})/p_j$.

[18] In the steady state, adjustment costs are zero, hence the goods-market equilibrium condition is consistent with national accounts concepts. In the short run, adjustment costs can be included as part of investment to be consistent with the structure of the national accounts, but since installation costs are generally very small (relative to output), this adjustment has little practical importance.

The model cannot be solved analytically, therefore numerical solutions are used. A static or steady-state version of the model is solved as a non-linear system using Newton's algorithm. The saddle-path dynamics resulting from shocks to the model are solved using the stacked Newton algorithm available in TROLL (see Armstrong et al. 1998). The model has eight non-predetermined variables (or jumpers): human wealth, the price of land, and the prices for the two types of capital in each of the three sectors. The standard Blanchard and Kahn (1980) stability and uniqueness conditions are satisfied for a linearized version of the model, but all simulations use the full non-linear model.

Before turning to calibration issues, it is useful to define several macro variables of interest in the context of the model. Since both non-tradables producers and manufacturers use inputs of the resource (intermediate) good in production, output in these sectors as defined above is gross output. The more familiar value-added concept, y_j^{va}, can be constructed by subtracting resource inputs:

$$y_j^{va} = \hat{y}_j - p_1 z_j / p_j . \tag{32}$$

Aggregate income or output at current prices, y^{va}, is determined by summing the value added of each sector, measured in terms of the manufactured good, the numeraire. This yields:

$$y^{va} = p_0 y_0^{va} + p_1 y_1^{va} + y_2^{va} . \tag{33}$$

In similar fashion, other macro aggregates, such as total investment or investment in structures, can be obtained by pricing them in terms of manufactured goods and summing across sectors.

Note that the choice of manufactured goods as the numeraire is arbitrary. An alternative approach is to measure macro aggregates in terms of the consumption basket. In the economy described above, there is a natural real consumer price index, *rcpi*, which is embodied in the expenditure function associated with the solution to the consumer's problem:

$$rcpi = \left(\frac{p_0}{\theta_0}\right)^{\theta_0} \left(\frac{p_1}{\theta_1}\right)^{\theta_1} \left(\frac{1}{1-\theta_0-\theta_1}\right)^{1-\theta_0-\theta_1} . \tag{34}$$

The *rcpi* is the relative price of the consumption basket in units of the manufactured good. Relative prices and aggregate quantities measured in terms of the manufactured good can therefore be converted into units of the consumption basket by dividing by *rcpi*.

The *rcpi* also provides a convenient means of defining the real exchange rate. In empirical work, the real exchange rate is typically measured as the ratio of a foreign aggregate price index to the corresponding domestic aggregate price index, all measured in a common currency. If we use consumption-based price indexes, the corresponding definition of the real exchange rate in the model is:

$$er \equiv \frac{rcpi^*}{rcpi}, \tag{35}$$

where *rcpi** is the real consumer price index in the rest of the world. If we assumed that *rcpi** has the same form as *rcpi* and the share weights in utility (the θs) are the same at home and abroad, the real exchange rate simplifies to:

$$er = \left(\frac{p_0^*}{p_0}\right)^{\theta_0}, \tag{36}$$

where p_0^* is the (exogenously determined) relative price of non-tradables in the rest of the world. For a given p_0^*, movements in the real exchange rate will therefore reflect supply-and-demand conditions for non-tradables in the domestic economy.

1.5 Model parameterization: Summary

For the purpose of simulation, the model is calibrated to capture the salient features of the Canadian economy based on three types of evidence: the input-output and final demand structure of the Canadian economy, average shares or ratios from aggregate time-series data, and econometric evidence from micro and macro studies. The details of the parameterization can be found in Appendix 2, and a complete list of the chosen parameter values is provided in Table 1.

The Canadian final-demand tables are used to compute the expenditure shares for both consumption and government purchases, and the input-output tables form the basis of the share parameters in production. Shares

Table 1
Simulation parameters

$\alpha_0 = 0.284$	$L = 1.000$	
$\alpha_1 = 0.416$	$\chi_1 = 0.040$	
$\alpha_2 = 0.256$	$\rho = 0.009$	
$\beta_0 = 0.057$	$\pi = 0.035$	
$\beta_2 = 0.109$	$\phi = 0.010$	
$\omega = 0.200$	$\Phi_0 = 0.895$	
$\theta_0 = 0.583$	$\Phi_1 = 1.331$	$\varphi = 2.000$
$\theta_1 = 0.060$	$\psi = 0.145$	$r = 0.040$
$\theta_2 = 0.357$	$\delta_{i0} = 0.030$	for $i = 0,1,2$
$\xi_0 = 0.880$	$\delta_{i2} = 0.120$	for $i = 0,1,2$
$\xi_1 = 0.040$	$\eta_{i0} = 2.500$	for $i = 0,1,2$
$\xi_2 = 0.080$	$\eta_{i2} = 1.500$	for $i = 0,1,2$
$\upsilon = 0.010$	$\sigma_{ij} = 0.648$	for $i = 0,1,2; j = 0,2$

are obtained from 1996 current-dollar figures at the *M*-level of aggregation.[19]

1.6 Nominal-wage rigidity

A well-known result in the economics literature is that nominal price or wage rigidity is necessary for the choice of an exchange rate regime to matter in the short run. However, the market-clearing model described above assumes that prices and wages are perfectly flexible. In this section, we overcome this limitation by assuming that consumer-workers and firms enter into nominal-wage contracts.[20] The optimization problems facing firms and consumers are not solved subject to the nominal contracts. Instead, the nominal contracts are simply overlaid on the market-clearing model. The basic form of the contract is that workers and firms set nominal wages to clear the labour market ex ante and, in return for a fixed nominal wage for the duration of the contract, workers agree to supply as much labour as the firm demands ex post. Let $W_{j,t-s}(t)$ be the nominal wage for transactions at time t set at time $t-s$ in sector j. At time t, non-tradables producers and manufacturers demand labour inputs:[21]

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[19] The *M*-level of aggregation is the "medium" level in the input-output and final-demand tables, and disaggregates into 50 industries and 50 goods.

[20] The form and implementation of the contracts considered in the model draw on work by King (1990), Cho and Cooley (1995), and Rankin (1998), and are closely related to the earlier work of Gray (1976) and Fischer (1977). For a review of the literature on nominal-price and wage setting, see Taylor (1998).

[21] With nominal-wage contracts, equation (17) changes to equation (37).

$$n_j(t) = \frac{P_2(t)p_j(t)[1-\alpha_j-\beta_j]y_j(t)}{W_{j,t-s}(t)}, \tag{37}$$

where P_2 is the nominal price of manufactured goods. Recall that manufactured goods are the numeraire in the model, so P_2p_j is the nominal price of good j and $W_{j,t-s}/P_2p_j$ is the producer real wage. Resource firms demand labour inputs:

$$n_1(t) = \frac{P_2(t)p_1(t)[1-\alpha_1-\omega]y_1(t)}{W_{j,t-s}(t)}. \tag{38}$$

The nominal wage for transactions at time t is set as the expectation at time $t - s$ of the nominal wage that would prevail in the market-clearing model at time t. For the non-tradables and manufacturing sectors, this gives:

$$W_{j,t-s}(t) = E_{t-s}\hat{P}_2(t)\hat{p}_j(t)[1-\alpha_j-\beta_j]\hat{y}_j(t)/\hat{n}_j(t), \tag{39}$$

where the hats over the right-hand-side variables denote market-clearing quantities and prices. A similar wage-setting equation is required for the resource sector. In equilibrium, nominal wages must be equal across sectors because labour is assumed to be perfectly mobile.

To make the nominal-wage contracts more realistic, the basic contract is embedded into a system of overlapping contracts. In each period, half of the contracts are set and are assumed to last two years. At any time t, half of the workers will therefore have one year left in their contract, and the other half will have two years. Nominal wages are set as in equation (40) to clear the labour market in an expected sense. Labour demand in each sector is then determined by the average wage:

$$W(t) = [W_{t-1}(t) + W_{t-2}(t)]/2, \tag{40}$$

and $W(t)$ replaces $W_{j,t-s}(t)$ in equations (38) and (39).

Finally, the model is closed by an exogenous monetary authority that controls the value of the nominal anchor. Several choices for the nominal anchor are possible. The monetary authority can fix the nominal exchange rate, thereby setting domestic inflation equal to foreign inflation in the long run. Alternatively, the monetary authority can allow the nominal exchange rate to float and achieve other goals, such as a constant nominal-price level or a given path for inflation. The analysis does not include important issues associated with the credibility and implementation of monetary policy; the monetary authority is assumed to be capable of achieving its target, providing that it targets a nominal variable.

1.7 Stochastic simulation procedure

To simulate the model, we choose a time horizon of 145 years for the economy and introduce random terms-of-trade shocks into the model in each period. We drop the first 10 years, so that the starting point does not affect the results, and then compute the means and standard deviations of aggregate employment, real income, consumption, and net foreign assets. Finally, we perform 100 replications of history and compute the average of the relevant moments across replications. Thus, the total number of simulations is 13,500. The shocks used in the experiments are the same across exchange rate regimes. Therefore, the results are comparable across exchange rate regimes. Although the shocks are unanticipated, it is assumed that agents know the path of each shock after it has occurred.

The terms of trade, p_1, is assumed to follow an AR(2) process. The distribution of the shock is based on the properties of the residuals from a regression of the terms of trade, proxied in the data by the relative price of non-energy commodities to manufacturing import prices, on a constant and two lags of the terms of trade, using annual Canadian data for the period 1975 to 1998. Since the residual from the estimated AR(2) model is i.i.d. with a standard error of 0.05, the shocks used in the model were constructed to capture this feature. The coefficients for the first and second period lags of the terms-of-trade variable in the estimated equation are 0.93 and –0.56, respectively.[22]

2 Analysis of Results

To isolate the economic consequences of introducing transactions costs in the economy under different exchange rate regimes, we begin with a stochastic version of the model with no transactions costs. Then we introduce endogenously determined transactions costs and compare the results. In each case, we focus on the volatilities of aggregate employment, real output, consumption, and net foreign assets under a fixed exchange rate and a flexible exchange rate regime with a consumer price index (CPI) inflation target. Finally, we examine the welfare costs of the introduction of a common currency in Canada.

2.1 Benchmark model

Simulation results for the stochastic version of the model with no transactions costs are presented in Table 3. They show that there is a trade-off

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[22] Table 2 reports selected ratios describing the initial steady state of the model.

Table 2
Steady-state ratios

	Aggregate	Non-tradables	Resources	Manufacturing
Share of output	1.00	0.59	0.23	0.18
Share of employment	1.00	0.64	0.15	0.21

Ratios of GDP			
Consumption	0.65	Government debt	0.78
Investment	0.12	Foreign assets	-0.39
Government	0.22	Capital	1.72
Exports	0.11	Imports	0.10

Table 3
Benchmark model

Standard deviation (x 100)	Fixed	Flexible
Aggregate income	3.24	2.20
Employment	1.63	0.54
Consumption	1.15	0.79
Net foreign assets	24.89	14.30

between the variance of the nominal exchange rate and that of key macroeconomic variables. In particular, aggregate income, employment, consumption, and net foreign assets are more volatile under a fixed exchange rate regime. The intuition for this result is as follows. Suppose that there is a temporary terms-of-trade deterioration. Under both regimes, the value of land and wealth fall as a result of the fall in the price of resources. This results in a decrease in the consumption of the non-tradable good, a fall in its price and, from equation (36), a real exchange rate depreciation.

In the flexible exchange rate regime with a CPI inflation target, the domestic price level (in terms of the manufactured good) rises; therefore, the real depreciation is achieved through a nominal exchange rate depreciation that is larger than the increase in the domestic price level.[23] Because wages are sticky, the increase in the domestic price level results in a decrease in real wages, thereby creating an incentive for firms in the non-tradable and manufactured goods sectors to absorb labour displaced from the resource sector. There is an increase in aggregate investment because of the decrease in the price of the non-tradable investment good and because the use of more inputs in the manufactured and non-tradable goods sectors increases the marginal product of capital. Aggregate income and consumption will also decline.

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[23] To understand why the domestic price level in terms of the manufactured good must rise when the monetary authority targets the inflation rate measured in terms of the CPI, note that the nominal CPI is the product of the real CPI and the domestic price level in terms of the manufactured good. The real CPI is increasing in the prices of resources and non-tradables. Therefore, when the prices of resources and non-tradables fall, the real CPI falls, implying that the domestic price level in terms of the manufactured good must rise to maintain the CPI inflation target.

In the fixed exchange rate regime, however, the real depreciation of the exchange rate required to clear the non-tradable goods market can be realized only through a decrease in the domestic price level. Because nominal wages are sticky, the decrease in the domestic price level results in an increase in the real wage and a decrease in aggregate employment, consumption, and investment. Although aggregate employment and consumption decline, as in the case of a flexible exchange rate with a CPI inflation target, the decrease in the two variables is larger under a fixed exchange rate regime.

The result that a fixed regime has a higher variance of employment has been emphasized in the literature. More interesting are the quantitative differences between the fixed and flexible regimes. In particular, employment is three times more variable under a fixed regime. This suggests that there are high costs to fixing the exchange rate in a small open economy. Unlike employment, the volatility of consumption in a fixed exchange rate regime is one and a half times that of a flexible exchange rate regime. The smaller difference in the volatility of consumption across regimes can be explained by the fact that agents are smoothing consumption in response to the shocks; they have perfect access to global capital markets at a fixed rate of interest. Because consumption is more volatile under the fixed exchange rate regime, consumers need to adjust their foreign asset positions more to smooth consumption. This explains the result that the volatility of net foreign assets is higher under a fixed exchange rate regime.

2.2 Adding transactions costs

To incorporate the microeconomic benefits of a permanently fixed exchange rate regime under a common currency, we assume that there are transactions costs associated with trade under flexible regimes. In particular, we assume that for every unit of a good imported or exported (under a flexible exchange rate regime), a certain percentage is lost by the economy (as in the familiar iceberg model) as a result of currency-conversion costs or costs associated with exchange rate uncertainty.[24] Ideally, the percentage of transactions costs paid by any agent would depend on the proportion of the traded goods used or exported by the agent. However, since there is no way of pinning down the proportion of the traded goods used or exported by any agent, we introduce the transactions costs as a loss to the economy as a whole. This implies that all agents in the economy share the costs equally.

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[24] Because the home country is a price taker in world markets, it is assumed to absorb transactions costs on both imports and exports.

Suppose x_1 and x_2 are net exports of goods 1 and 2, respectively, where x_2 is negative because the small country is assumed to import good 2 (manufactured goods). To sell x_1 units of good 1 on the world market, the resource sector would have to ship $\hat{x}_1 = (1+\chi)x_1$ units of good 1, since χx_1 represents transactions costs. Similarly, if the economy imports x_2 units of good 2, it pays χx_2 in transactions costs so that the amount available to agents for consumption or investment is actually $\hat{x}_2 = (1-\chi)x_2$. Because these costs are incurred only in flexible regimes, χ is a function of the exchange rate regime. To make this dependence explicit, we assume that $\chi = \chi_1 \sigma_{EN}$, where σ_{EN} is the standard deviation of the nominal exchange rate.

The inclusion of transactions costs alters the market-clearing conditions for goods 1 and 2 (tradables). The modified equations are:

$$\tilde{y}_1 = c_1 + z_0 + z_2 + \gamma_{10} + \gamma_{12} + g_1 + (1+\chi)x_1, \tag{41}$$

$$\tilde{y}_2 = c_2 + i_{02} + i_{12} + i_{22} + \gamma_{20} + \gamma_{22} + g_2 + (1-\chi)x_2. \tag{42}$$

In the calibration experiments, the transactions costs parameter, χ_1, was determined as follows. Laidler and Robson (1991) suggest that the transactions costs associated with a flexible exchange rate are about 0.2 per cent of GDP in Canada.[25] In addition, net exports of resources and net imports of manufactured goods represent about 21 per cent of GDP in the model. In the model, there is no intra-industry trade: resources are not imported and manufactured goods are not exported. In practice, however, this is not the case. Therefore, the trade-GDP ratio of 21 per cent obtained in the model (11 per cent resource exports and 10 per cent manufactured imports) has to be grossed upwards to 41 per cent to reflect the volume of intra-industry trade. Transactions costs of about 0.2 per cent of GDP and an adjusted trade-GDP ratio of 41 per cent imply that transactions costs represent roughly 0.5 per cent of trade in Canada. Setting the ratio of transactions costs to trade, χ, at 0.005, we can compute χ_1 given the observed standard deviation of the nominal exchange rate, σ_{EN}. Between 1990 and 1999, the standard deviation of the nominal exchange rate in Canada was 0.12. Therefore, the transactions costs parameter, χ_1, is 0.04.[26]

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[25] Although transactions costs are difficult to quantify, Grubel (1999) suggests that for Canada, the United States, and Mexico, they are 0.1 per cent of national income. Therefore, the 0.2 per cent figure used in this paper is probably an overestimate and may bias the results against flexible exchange rate regimes.

For most variables of interest, the simulation results for the model with endogenous transactions costs are similar to those of the model without transactions costs. For example, aggregate income, employment, and consumption are still more variable under the fixed exchange rate, compared with the flexible exchange rate regime (see Table 4). The similarity between the volatilities of key macroeconomic variables in the model with and without transactions costs is not surprising. Transactions costs are essentially a tax on trade that affects the mean level of consumption and not the volatilities of macroeconomic variables.

2.3 Adding credit constraints

Thus far, we have assumed that consumers have access to an international capital market and can borrow to smooth consumption. In practice, however, many consumers cannot borrow and lend to insulate themselves from terms-of-trade shocks at a fixed rate of interest. In this section, we introduce more realism into the model by imposing restrictions on borrowing. We assume that younger agents are initially denied access to credit markets, because agents are born without wealth and, hence, can consume only from current disposable income. If we assume that a generation "graduates" out of this pool just as another is born into it, then in each period, a proportion, Ω, of credit-constrained agents exists in the economy. Relative to the benchmark model, the introduction of credit constraints changes the structure of the aggregate consumption function in equation (1). Specifically, if c^{cc} and c^{ncc} represent aggregate consumption for credit-constrained and non-credit-constrained agents, respectively, the aggregate consumption equation in the economy takes the form:

$$
\begin{aligned}
c &= c^{cc} + c^{ncc}, \\
c^{cc} &= \Omega[(1-\Lambda)w - \tau], \\
c^{ncc} &= \frac{1}{\Delta}[a + (1-\Omega)h]. \qquad (43)
\end{aligned}
$$

In equation (43), aggregate consumption is the sum of consumption by credit-constrained and non-credit-constrained agents. Agents with the

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[26] The standard deviation of the nominal exchange rate in the model is obtained using an iterative procedure that takes the observed value in the data as its starting value.

Table 4
Transactions costs

Standard deviation (x 100)	Fixed	Flexible
Aggregate income	3.24	2.20
Employment	1.63	0.54
Consumption	1.15	0.79
Net foreign assets	24.89	14.11

ability to borrow consume based on permanent income, while credit-constrained agents consume their current disposable income.

In the simulations, the credit-constraint parameter, Ω, was set equal to 0.5, based on the work of Wirjanto (1995). Simulation results for the model with credit-constrained consumers are presented in Table 5. There are two important points to note here. First, relative to the benchmark model, the introduction of capital-market imperfection increases the magnitude of the difference in the volatilities of employment, output, and consumption between the two exchange rate regimes. In particular, employment is 3.5 times more volatile in a fixed exchange regime as compared with 3 in the benchmark model, and consumption is 2 times more volatile compared with 1.5 in the benchmark model. Also, income is 1.6 times more volatile, rather than 1.5, as in the benchmark model. Second, the volatility of consumption in a fixed exchange rate regime is now closer to that of employment, because some agents in the model can no longer smooth consumption by borrowing.

2.4 Extreme-value shocks

Recent experience with the collapse of fixed exchange rate regimes has shown that the stabilization benefits of flexible exchange rate regimes are more noticeable in economies subject to extremely large shocks, as observed during the 1997–98 Asian currency crises. However, the stochastic-simulation experiments performed with the benchmark model assumed that shocks were drawn from a normal distribution. To capture the impact of the type of shock that hit the Canadian economy during the Asian crisis, this section examines the economic consequences of the introduction of extreme-value (or fat-tailed) shocks, with low probabilities of occurrence, for the choice of exchange rate regimes in the model. The fat-tailed shocks we consider are drawn from a *t*-distribution with three degrees of freedom.[27]

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[27] The *t*-distribution was chosen because it has been widely used in the economics and finance literature to capture fat-tailed shocks. Andrews (1993) and Nankervis and Savin (1996) have used this distribution.

Table 5
Credit constraints

Standard deviation (x 100)	Fixed	Flexible
Aggregate income	3.57	2.20
Employment	2.01	0.57
Consumption	1.94	0.98
Net foreign assets	8.87	5.61

The degree of freedom was chosen to generate shocks of approximately the same order of magnitude as observed during the Asian currency crisis.

Table 6 presents results for the model with extreme-value shocks. As expected, the introduction of extreme states increases the volatilities of aggregate income, employment, and consumption relative to versions of the model with normally distributed shocks.

3 Welfare Analysis

We have argued that transactions costs are lower under a fixed exchange rate regime, but that a fixed rate regime generates volatility of real macroeconomic variables that are higher than what would be observed under a flexible regime. The next question, therefore, is how to map these differences in the behaviour of macroeconomic variables between the two regimes into a welfare measure. The OLG structure of our model implies that different generations of consumers exist in the economy in each period. This makes welfare analysis difficult, because it is not clear what the most appropriate method of aggregating welfare across generations is in this context.[28]

We deal with this problem by focusing on the welfare of an average consumer. The welfare concept adopted is that of equivalent variation, i.e., the percentage of consumption an average consumer would have to receive in the fixed exchange rate regime to be as well off as in a flexible regime. Specifically, to compute the welfare cost of a common currency, we find the value of λ satisfying equation (44) and then average across 100 replications.

$$\sum_{j=1}^{T}\left(\frac{1}{1+\rho}\right)^{j}\frac{[u_j(c_{fix}(1+\lambda))]^{1-\varphi}}{1-\varphi} = \sum_{j=1}^{T}\left(\frac{1}{1+\rho}\right)^{j}\frac{[u_j(c_{flex})]^{1-\varphi}}{1-\varphi}, \quad (44)$$

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[28] For further details, see Calvo and Obstfeld (1988).

Table 6
Fat-tailed distribution

Standard deviation (x 100)	Fixed	Flexible
Aggregate income	5.67	3.59
Employment	3.21	1.33
Consumption	3.11	1.71
Net foreign assets	14.12	9.21

where $u_j(c_{fix})$ and $u_j(c_{flex})$ represent utility of an average consumer at time j in a fixed exchange rate and in a flexible exchange rate regime, respectively. In the simulations, we set T equal to 100.

The welfare costs of a common currency for different versions of the model are presented in Table 7. The first row shows that the welfare cost of a common currency in the benchmark model is about 0.12 per cent of consumption. Introducing transactions costs into the model results in a decrease in the welfare cost of a common currency from 0.12 to 0.11 per cent of consumption. This makes sense, because transactions costs are essentially a tax on trade and hence reduce the level of consumption under a flexible regime. For the model with credit constraints and transactions costs, the welfare cost of a common currency is about 0.12 per cent. Comparing this result with the model with transactions costs but no credit constraints, we see that the welfare cost of a common currency is higher in an economy with credit constraints. This can be attributed to the fact that credit constraints limit the ability of consumers to smooth consumption. Turning to the model with an extreme-value distribution, we see that the welfare cost of a common currency is now 0.15 per cent. This supports our initial contention that the benefit of a flexible exchange rate regime is more noticeable in economies that are subject to large shocks.

An experiment was performed to determine the sensitivity of our results to the risk-aversion parameter. In this case, we increased the parameter from 2 (the benchmark value) to 5. This resulted in an increase in the welfare cost of a common currency to 0.17 per cent of consumption, which suggests that the cost of losing the nominal exchange rate as an instrument of adjustment is likely to be higher in economies with highly risk-averse agents and capital-market imperfections.

Since our welfare results may depend on the value of the transactions costs parameter—and there is no consensus on the true value of this parameter—we decided to approach the welfare issue from another perspective. Specifically, we asked the following question: what would the transactions costs parameter have to be for consumers to be indifferent between a common currency and a flexible exchange rate regime? It turns out that in

Table 7
Welfare costs of a common currency

Model	Welfare cost (% of consumption)
Benchmark	0.12
Transactions costs	0.11
Credit constraints	0.12
Fat-tailed distribution	0.15
Higher risk aversion ($\varphi = 5$)	0.17

the model with credit constraints (row 1 of Table 8), transactions costs would have to be at least 1.9 per cent of total trade, equivalent to about 0.8 per cent of GDP, given a trade-to-GDP ratio of 41 per cent.

For the model with credit constraints and high risk aversion (row 2 of Table 8), our simulation results suggest that transactions costs would have to be about 2.4 per cent of total trade (about 1 per cent of GDP) for consumers to be indifferent between a common currency and a flexible exchange rate regime. Given that the estimated savings in transactions costs for the 11 countries in the European monetary union is about 0.5 per cent of GDP, it is unlikely that the ratio of transactions costs to GDP in Canada would be more than 0.5 per cent. Since the ratio of transactions costs to GDP required for an average consumer to be indifferent between the two exchange rate regimes is more than 0.5 per cent of GDP, we are left with the conclusion that welfare is higher under a flexible exchange rate regime.

Concluding Remarks

This paper analyzes the economic and welfare consequences for Canada of two alternative exchange rate and monetary policy rules—a flexible exchange rate regime with a price-level target, which is similar to the existing regime, and a permanent fixed exchange rate, which might occur with the formation of a North American monetary union—using a stochastic DGE model of a small open economy with three sectors—resources, non-traded goods, and manufactures. The model is calibrated to recent Canadian data and then simulated to determine the impact of stochastic terms-of-trade shocks on key macroeconomic variables, including output, employment, consumption, and welfare under the two regimes. To examine the robustness of the results, a wide range of scenarios are considered: different assumptions are made concerning nominal-wage rigidities, transactions costs in international trade, credit constraints, the magnitude of the shocks, and risk aversion. At the heart of this comparison is the critical trade-off between the macro-stability benefits provided by a flexible rate and the

Table 8
Transactions costs required for consumer indifference

	Transactions costs (% of trade)	Transactions costs (% of GDP)
Credit constraints model	1.9	0.8
Higher risk-aversion model ($\varphi = 5$)	2.4	1.0

micro-efficiency gains resulting from the elimination of exchange rate uncertainty under a fixed rate. The basic result is that the flexible regime dominates under most assumptions: macroeconomic aggregates are less volatile and welfare is marginally higher.

In the benchmark model, two-period nominal-wage contracts are overlaid on the market-clearing version of the model. The simulation of a series of stochastic terms-of-trade shocks produces the standard result that a permanently fixed exchange rate produces more variable employment, output, and consumption, as well as lower welfare (0.12 per cent of consumption measured by the equivalent variation) as compared with the flexible rate. Under the nominal-wage rigidity, the flexible exchange rate generates a more flexible real exchange rate and real wage rate that facilitate adjustment to the shocks.

Small transactions costs in international trade are then added to the model: these costs are assumed to be positively related to exchange rate volatility. Approximately 0.5 per cent of imports and exports are consumed by such costs, and they lower the mean levels of consumption under the flexible rate. The welfare differential, however, is reduced only slightly to 0.11 per cent of consumption. Indeed, transactions costs would have to be relatively high—almost 1.9 per cent of trade for the welfare differential to be eliminated.

Next, we assume that 50 per cent of agents are credit-constrained. This premise makes the model more realistic, because it departs from the initial assumption that agents have unfettered access to the international capital market—which allows them to borrow and lend at a fixed world interest rate to smooth consumption—and from the assumption that agents are identical—which implies that there is no idiosyncratic terms-of-trade risk, only aggregate risk. Hence, when employment falls, for example, no one agent or group of agents lose their job, since the employment loss is shared equally. The effect of imposing the credit constraint is to increase the welfare differential in favour of the flexible rate to approximately 0.12 per cent of consumption.

Finally, extreme values of the terms-of-trade shocks are used in an effort to mimic the impact of a commodity price shock like the one that occurred during the East Asian financial crisis of 1997–98. This again has the effect of widening the welfare differential in favour of the flexible exchange rate to 0.15 per cent of consumption.

In the next version of the paper, we want to examine the impact a reduction in reliance on commodity exports would have on the choice of exchange rate regimes in Canada. Our results thus far imply that the transactions costs associated with a flexible rate do not exceed the losses resulting from volatility of output and employment under a fixed exchange rate. However, it is possible to envision ongoing processes that could reverse this inequality sometime in the future. In particular, exchange-rate-related transactions costs could increase over time as trade flows between Canada and the United States increased.[29] Furthermore, it is likely that Canada's endowment of productive factors, and therefore its industrial base, will come to more closely resemble that of the United States, as human and physical capital accumulate and technology is transferred. Consequently, Canada's relative reliance on natural resources would diminish, and the external shocks affecting the two economies would become less asymmetric. Hence, the benefit of having a flexible exchange rate serve as a macroeconomic buffer would be reduced. To capture this process, we will extend the model by incorporating a third manufacturing sector that could export. With this modification, terms-of-trade shocks would generate less macroeconomic instability, and the macroeconomic adjustment benefits of a flexible exchange rate would be reduced.

This paper makes an important contribution, because it represents one of the first attempts to quantify the macroeconomic costs and benefits of alternative exchange rate regimes in Canada, using a calibrated stochastic DGE model. It also provides important insights into the impact of different market rigidities. Indeed, it provides a useful framework for other small open economies considering entry into a monetary union.

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[29] We are assuming here that as the volume of trade increases (i.e., the country becomes more open), the asymmetric nature of the shocks remains unchanged. Krugman (1993) and others have argued that as openness increases, the asymmetry of the shocks may rise as countries become more specialized in production.

Appendix 1
Variable and Parameter Mnemonics

Conventions

good 0	non-tradables
good 1	resources
good 2	manufactured goods

All relative prices are measured in units of manufactured goods.

All quantity variables are measured per productivity adjusted worker.

Variables

a	non-human wealth
b	government debt
c	total consumption
c_j	consumption of good j
ca	current account
en	nominal exchange rate
er	real exchange rate
f	foreign assets
g	total government expenditure
g_j	government purchases of good j
h	human wealth
i	total investment
k_j	index of capital in sector j
k_{ij}	type i capital used in sector j
L	fixed stock of land
n_j	labour employed in sector j
p_0	relative price of non-tradables
p_1	relative price of resources = the terms of trade
P_j	nominal price of good j
p_L	price of land (detrended)
q_{ij}	the value of type j capital in sector i
r	world real interest rate
$rcpi$	real consumer price index
w	real wage

W	nominal wage
$W_{t-s}(t)$	nominal wage at time t set at time $t-s$
x_j	exports of good j
y_j	gross output of sector j
$\tilde{y}_j$	gross output of sector j net of transactions-cost cum risk premium
y_j^{va}	value added of sector j
y^{va}	aggregate income
z_j	resource inputs in sector j
γ_{ij}	adjustment costs in the installation of type j capital in sector i
τ	taxes
E_{t-s}	expectation conditional on time $t-s$ information

Parameters

α_j	capital's share in sector j
β_j	resource input's share in sector j
δ_{ij}	depreciation rate of type j capital in sector i
η_{ij}	adjustment costs parameter for type j capital in sector i
θ_j	expenditure share weight for consumption of good j
Λ	amount of time consumers take in leisure
μ	parameter in government's consumer tax rule
υ	rate of population growth
ξ_j	expenditure share weight for government consumption of good j
π	probability of death
ρ	pure rate of time preference
σ_0	share of structures in total capital
ϕ	rate of labour-augmenting technical progress
Φ_j	level of productivity in sector j
ψ	premium in the firm's discount rate
ω	share of land in resource production
χ_1	transactions costs parameter
Ω	liquidity-constraint parameter

Appendix 2
Parameterization of the Model

The expenditure and input shares used in the calibration are based on the following classification of non-tradables, resources, and manufactured goods. The non-tradables sector includes construction; transportation and storage; communications; insurance, finance, and real estate;[1] community and personal services; and the unallocated portion of final demand (almost all of which is government services). This definition of non-tradables is consistent with the international classification adopted by Summers, Kravis, and Heston (1980), except that they do not include government services, but do include utilities (electricity, gas, and water). In the context of the Canadian economy, utilities would seem to fit more naturally in the resource sector, since Canada exports electricity.[2]

The resource sector is defined to include primary industries, resource processing, and utilities. The primary industries are agriculture, fishing, forestry, and mining; and resource processing includes pulp and paper, wood products, primary metals, chemicals, and petroleum and coal refining. The decision to include processing in the resource sector reflects the integrated nature of many resource industries and the view that including processing in manufacturing (as in the national accounts) understates the importance of the resource sector. The manufacturing sector is defined residually as anything that is neither non-tradables nor resources.

As shown in Table 1, the share of non-tradables in consumption is 58.3 per cent, followed by manufacturing goods at 35.7 per cent, while the government spends 88 per cent of its budget on non-tradables. The input-output tables do not explicitly account for inputs of land. Following Stuber (1988), the share of land in the production of resources is set at 20 per cent, implying returns to scale in this sector of 80 per cent. The stock of land is normalized to unity.

The parameters governing the evolution of capital and labour are based on average ratios in the data, or they draw on other studies. Capital is assumed to depreciate at the same rate in all three sectors and, following Macklem (1993b), the depreciation rates for structures and machinery are set at 3 per cent and 12 per cent, respectively. Capital of both types is defined to include private sector and government capital, and structures is defined to include housing as well as non-residential construction. Although the sectors differ in their capital intensities, all three sectors are also assumed to combine structures and machinery in the same proportion to form the composite capital good that enters the production function. From 1986 to 1999, the stock of structures averaged about three times the stock of machinery. The share parameter σ in the model is chosen to deliver this 3-to-1 ratio; this requires a value for σ of 0.648. Following Macklem (1993b), the adjustment-cost parameters for structures are set at 2.5 and those for machinery are set at 1.5.

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[1] Real estate includes the imputed return to owner-occupied dwellings.

[2] Unallocated demand is included in non-tradables so that the production of all three sectors sums to GDP.

The initial levels of productivity in the resource and manufacturing sectors (the Φs) are chosen so that the small economy exports resources and imports manufactured goods in the initial steady state. In Canada, net exports of resources and net imports of manufactured goods have both averaged between 11 per cent and 12 per cent of GDP. In the model, the initial level of productivity in the manufacturing sector is normalized to unity, and the initial level of productivity in the resource sector is set at 1.331 to deliver a steady-state exports-to-GDP ratio of 11 per cent. The initial level of productivity in the non-tradables sector is normalized such that the price of non-tradables relative to manufactured goods is unity. Since the terms of trade is also normalized to unity, all three goods have the same relative price in the initial steady state.

The government sector in the model is calibrated to match average shares obtained from aggregate time-series data. Consumer taxes are set at a level sufficient to sustain government expenditures at 22 per cent of GDP with a debt-to-GDP ratio of 78 per cent.

This leaves three unassigned parameters in the model—the probability of death, rate of time preference, and the premium in the firm's discount rate. The probability of death is set at 3.5 per cent, which implies that consumers have a horizon of about 30 years. The rate of time preference is chosen so that the ratio of foreign assets to GDP in the model is –39 per cent, which, based on historical experience, is roughly consistent with a government debt-to-GDP ratio of 78 per cent. The rate of time preference required to deliver the –39 per cent ratio is about 1 per cent, which is well within the plausible range. The premium that enters the firm's discount rate and the capital-to-GDP ratio were set at 14 and 172 per cent, respectively, to match the values used in the Quarterly Projection Model (QPM) of the Bank of Canada.

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Discussion

Steven Ambler

Introduction

I congratulate the authors on a tour de force of dynamic general-equilibrium (DGE) modelling. The paper takes as its starting point the basic intuition (well summarized by the authors on page 5 of this volume) that the choice of exchange rate regime is a "trade-off between the microeconomic efficiency gains (i.e., the reduction in transactions costs) resulting from a common currency versus the gains in macroeconomic stabilization provided by a flexible rate adjusting to asymmetric exogenous shocks." As the authors note, the existing literature does not adequately capture the trade-off in a rigorous theoretical framework.

The authors set out to do just this by creating a calibrated DGE model of the Canadian economy. The model includes nominal rigidities and a disaggregation of the economy into non-tradables, resources, and manufactured goods. It allows them to capture the terms-of-trade shocks that have hit the Canadian economy and to model the possibility of credit constraints affecting a subset of consumers. The authors simulate the model under flexible and fixed exchange rates and evaluate the welfare improvement under flexible rates from the economy's improved ability to absorb terms-of-trade shocks. They show that the savings in transactions costs from a fixed exchange rate regime would have to be implausibly large to outweigh the macroeconomic benefits of a flexible rate arrangement.

The paper's basic intuition also underpins the classic paper by Mundell (1961) on optimal currency areas and much of the theoretical literature on exchange rate regime choice. Since the granting of the 1999 Nobel prize in economics to Robert Mundell, there has been a re-examination of his ideas and their evolution. How can the Mundell of the optimal-currency-areas paper have been such a fervent supporter of European monetary union, to the extent that he has been dubbed by some as the "father of the euro"? According to McKinnon (2000), the answer is that there are, in fact, two Mundells: the 1960s version, author of the paper on optimal currency areas and of papers on the workings of fiscal and monetary policy under alternative exchange rate regimes; and the 1970s incarnation, advocate of European monetary union and author of two papers (1973a, 1973b) that have not enjoyed the high profile of the earlier work. The later Mundell recognized the importance of expectations and (implicitly) the existence of many types of shocks other than asymmetric real shocks. My criticisms of the paper and its results should be seen as coming from the perspective of the second Mundell.

Section 1 of this discussion summarizes the model's structure. I try to motivate some of the assumptions that are not explicitly motivated in the paper. I underline the assumptions that I believe crucial for the results, and I also point out several assumptions that may render the model needlessly complicated. In section 2, I attempt to provide intuition for the main results of the paper in regard to the effects of terms-of-trade shocks on the market-clearing nominal wage under different exchange rate regimes. In section 3, I criticize the model for what it does not accomplish. The final section concludes.

1 Model Structure and Key Assumptions

1.1 Production and stochastic shocks

The economy produces three goods: resources ("good one" in the model), manufactures ("good two"), both of which are tradable at given prices on world markets; and a non-tradable good ("good zero"). Resources are produced with a constant returns to scale (CRS) production function with labour, capital, and land as inputs. The other two goods are produced with CRS production functions, using labour, capital, and resources. Productivity parameters and relative prices are calibrated so that resources are exported and manufactures are imported in equilibrium. The main results of the model arise from terms-of-trade shocks between manufactures and resources. I'm not sure how much the addition of non-traded goods adds to the model, other than implying that the real exchange rate as defined in equation (35) and simplified in equation (36) becomes a constant as the share of non-tradables shrinks to zero. Since the authors do not use the model's predictions concerning real exchange rate variability to evaluate its performance, they could probably dispense with non-tradables altogether.

Capital in each sector is an aggregate of a capital good from the non-tradables sector and a capital good from the manufacturing sector. Investment is subject to convex adjustment costs, and the resource constraints (24), (25), and (26) tell us that the adjustment costs are paid in units of the good produced by the sector in which investment takes place. There is always a modelling choice to be made in multi-sector models about how the output of different sectors is aggregated into consumption and investment goods. The authors have made one possible choice, but do not tell us what considerations led to this choice or whether the results are sensitive to it. The choice does lead to a large number of asset-pricing relationships, and there are six Tobin's q's, one for each type of capital good in each sector. This must make obtaining the desired saddle-point stability properties much more difficult.

The economy is a small open economy, thus the terms of trade between resources and manufactured goods are exogenous. Fluctuations in the terms of trade are the only source of uncertainty in the model, therefore it is appropriate to discuss them here. The terms of trade are modelled as a second-order autoregressive process, with either normal errors or errors drawn from a *t*-distribution with three degrees of freedom to capture the possibility of fat-tailed shocks. One thing the authors could easily do, but don't, is test the normality of the errors in their estimated equation.

1.2 Consumers

There is a growing population of consumers in the model who face a constant probability of death, as in Blanchard (1985). This assumption is clearly needed to map preference parameters into the steady-state level of net foreign assets when the model is calibrated. With infinite horizons and a rate of time preference equal to the gross world real interest rate, agents save any positive shock to current income and live off of the interest. Net foreign assets follow a random walk. When the model is simulated, they can wander arbitrarily far from their calibrated initial level.

1.3 Government

Government spending grows exogenously at a fixed rate equal to the economy's overall growth rate. The government allocates fixed proportions of total spending to the three types of goods. Once trend growth is removed, government spending in each sector acts as little more than a negative constant in the production function, making less output available for private sector use. The model could be simplified by omitting government spending altogether, especially since the interaction between the fiscal and monetary authorities is not modelled at all. I conjecture that the authors chose to incorporate government spending to simplify the calibration exercise. This inclusion opens up the possibility of examining the effects of fiscal spending shocks in future work.

1.4 Prices

How prices are determined in the model is absolutely crucial to the results, therefore this feature is worth summarizing.

Manufactured goods are taken as the numeraire in the model. The relative price of resources, p_1, is exogenous and measures the terms of trade for the Canadian economy. The relative price of non-tradables, p_0, is endogenous and determined by supply-and-demand conditions in the market for non-tradables.

The monetary authority in the model merely provides a nominal anchor to the system. Under fixed exchange rates, the anchor is obviously the exchange rate itself. Under flexible exchange rates, the monetary authority is assumed to fix (either in levels or in rates of change) the overall consumer price index.

The nominal price of manufactured goods is given by $P_2 = eP_2^*$, where e is the nominal exchange rate, and P_2^* is the nominal price of foreign manufactures. The nominal prices of non-tradables and resources are, respectively, $P_0 = p_0 P_2$ and $P_1 = p_1 P_2$. The nominal price level is:

$$P = \left(\frac{P_0}{\theta_0}\right)^{\theta_0}\left(\frac{P_1}{\theta_1}\right)^{\theta_1}\left(\frac{P_2}{1-\theta_0-\theta_1}\right)^{1-\theta_0-\theta_1},$$

$$\rightarrow P = \left(\frac{p_0 P_2}{\theta_0}\right)^{\theta_0}\left(\frac{p_1 P_2}{\theta_1}\right)^{\theta_1}\left(\frac{P_2}{1-\theta_0-\theta_1}\right)^{1-\theta_0-\theta_1}.$$

Under fixed exchange rates, P_2 is unaffected by a terms-of-trade shock, while under flexible rates, the price level, P, is fixed, and P_2 is determined endogenously as the solution to the above equation.

1.5 Labour market

Consumers have a given labour endowment, and they supply labour inelastically. This assumption clearly makes solving the model much simpler, but it must have important consequences for the welfare analysis that the authors undertake. Without leisure in the utility function, there are no direct welfare consequences of unexpected movements in employment due to wage rigidity. Any impact of shocks on welfare due to wage rigidity must arise from the indirect effects of shocks on consumption, capital accumulation, and other variables. I suspect this is why the introduction of credit constraints makes such a difference in welfare terms. For agents who are credit-constrained, involuntary changes in hours worked lead directly to large changes in current consumption, since the impact of changes in current income on consumption cannot be smoothed by lending and borrowing.

My guess is that if leisure were to be put in the utility function, the direct impact of unintended fluctuations in hours on welfare would dominate any of the indirect effects. For this reason, the authors may be understating the impact of the choice of exchange rate regime on welfare. Given the small quantitative differences between welfare levels under different exchange rate regimes (fractions of 1 per cent of aggregate consumption), it would be important to extend the model to include leisure in the utility function.

2 Understanding the Results

The model's welfare gains from a flexible exchange rate are large enough that they swamp any possible estimate of the transaction cost savings of going to a fixed exchange rate. This is a strong result. The model is a relatively complex DGE model that cannot be solved analytically, therefore the features driving the results may seem unclear. But, I believe the basic thrust of the results could be understood in terms of a much simpler model.

Consider a simple two-sector model where both goods are tradable. Call sector one the exportable good or resources and sector two the importable good or manufactures. Production is based on CRS functions, using only capital and labour as inputs.[1] These sectoral production functions can be written as:

$$y_1 = \Phi_1 k_1^{\alpha_1} l_1^{1-\alpha_1},$$

$$y_2 = \Phi_2 k_2^{\alpha_2} l_2^{1-\alpha_2},$$

using notation similar to that of the paper. Given these assumptions, it is possible to compute the equilibrium or market-clearing nominal wage without reference to the demand side of the model other than the equation for the price level. Compared with the authors' model, the latter is quite simple and can be written as:

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[1] I assume that factor prices are such that complete specialization is not an equilibrium.

$$P = \left(\frac{p_1 P_2}{\theta_1}\right)^{\theta_1}\left(\frac{P_2}{1-\theta_1}\right)^{1-\theta_1} .$$

Labour demand in each sector is a function of the (common) nominal wage, the sectoral capital stock, and the nominal price of sectoral output. The sectoral labour demand curves are shown in the first two panels of Figure 1. The third panel shows labour market equilibrium, determined by the intersection of labour supply and labour demand curves at point *A*, assuming that the aggregate labour supply curve is inelastic, as it is in the paper.

The impact on the equilibrium nominal wage under a fixed exchange rate regime is illustrated in Figure 2. Under a fixed exchange trade, an increase in the relative price of exportables leads to no increase in the nominal price of importables (assuming that the terms-of-trade shift comes about through an increase in the foreign price of exportables), leaving the labour demand curve in sector two unaffected. The nominal price of exportables increases proportionally to the relative price increase. This, in turn, shifts the labour demand curve in the exportables sector to the right. The aggregate labour demand curve also shifts to the right, and the equilibrium in the labour market shifts from point *A* to point *B*. The equilibrium nominal wage increases unambiguously. If wages are predetermined at the expected market-clearing level, a disequilibrium in the labour market results. Workers are forced to work more than anticipated. There are no direct effects on welfare, since leisure is not in the utility function, but there are indirect effects via the impact on consumption and other variables.

The impact on the equilibrium nominal-wage rate is quite different under flexible exchange rates, as illustrated in Figure 3. If the monetary authority has some fixed target for the overall price level that is not sensitive to the terms-of-trade shock, the price of importables must decrease (or at least increase by less than expectations), and the price of exportables must increase less than proportionally to the change in the terms of trade. It is easy to show that:

$$\frac{dP_2}{P_2} = -\theta_1 \frac{dp_1}{p_1},$$

and

$$\frac{dP_1}{P_1} = (1-\theta_1)\frac{dp_1}{p_1}.$$

Figure 1
Labour market equilibrium

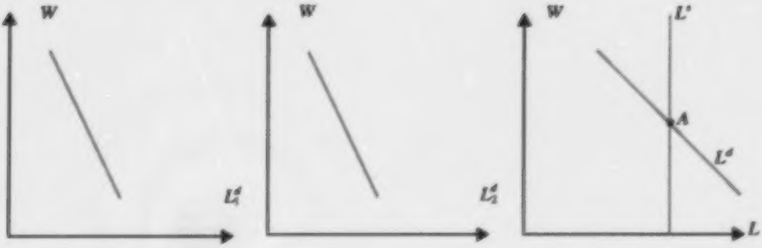

W
L_1^d
W
L_2^d
W
L^s
A
L^d
L

Figure 2
Terms-of-trade shock—fixed rates

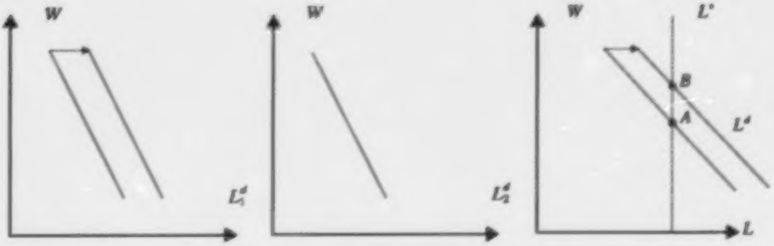
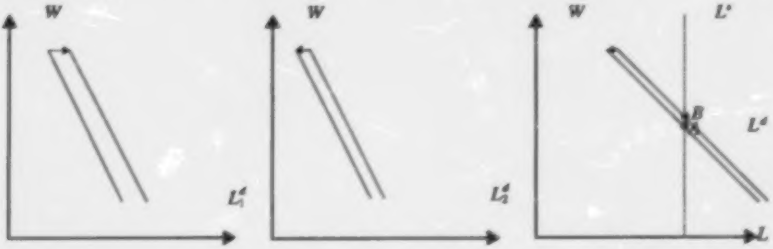

W
L_1^d
W
L_2^d
W
L^s
B
A
L^d
L

Figure 3
Terms-of-trade shock—flexible rates


W
L_1^d
W
L_2^d
W
L^s
B
A
L^d
L

The labour demand curve in the importables sector shifts to the left, and the labour demand curve in sector one shifts to the right, but by less than the shift under a fixed exchange rate regime. The increase in aggregate labour demand must be less than under a fixed exchange rate, so that the increase in the equilibrium nominal wage is also less. This is the sense in which flexible exchange rates facilitate macroeconomic adjustment to terms-of-trade shocks. In fact, there is a value of θ_1 for which the shifts in the two sectoral labour demand curves offset one another, leaving the equilibrium (market-clearing) nominal wage completely unaffected by terms-of-trade shocks. Consequently, if the equilibrium nominal wage is unaffected, the welfare costs of wage rigidity under flexible exchange rates vanish completely.

The preceding paragraphs illustrate why the impact of a terms-of-trade shock on the market-clearing nominal wage is important, and why the nominal anchor of the monetary authority and the model's parameter values are important factors in determining the size of this shift. It would be extremely useful if the authors could measure the volatility of the market-clearing nominal wage under their fixed and floating-rate regimes, by running simulations in which contracts are turned off, in addition to simulations in which they are operative. This would help to show whether the intuitive arguments of the preceding paragraphs are correct, and to measure the intuition's quantitative importance. The authors only compare the welfare levels of fixed and flexible exchange rate regimes with wage contracts. It would also be interesting to compare the level of welfare under flexible rates and wage contracts with the first-best equilibrium when wages are perfectly flexible.

3 What's Missing

In the model, fluctuations in real exchange rates are optimal responses to real shocks. Nominal wage rigidities act as sand in the works, dampening the response of real exchange rates under fixed exchange rates. This is most certainly not what is in the minds of those who advocate fixed exchange rates because of the "excessive" volatility of real exchange rates under flexible rates. Mundell states this view very forcefully in his Nobel prize lecture, when he talks about "the dysfunctional volatility of exchange rates that could sour international relations in time of crisis" (2000, 339). This is also clear in the writings of other Canadian advocates of a North American currency union (for example, Courchene and Harris 1999). Although the authors do not report this, I am sure that the model doesn't reproduce the observed variability of the Canadian real exchange rate.[2]

One of the arguments put forward by the "1970s Mundell" in support of the superiority of single-currency areas is that they afford increased possibilities to share risks when private-capital markets have limited ability to facilitate consumption insurance. Ching and Devereux (2000) construct a simple model that captures the arguments of both Mundell (1961) and Mundell (1973) in a simple, unified framework. In response to a temporary negative domestic productivity shock under a fixed common-currency regime, domestic agents can draw down their cash balances to smooth their consumption. World prices rise, reducing the real value of foreign agents' cash balances. Consumption at home and abroad falls, and the common currency provides for some degree of risk-sharing in the face of asymmetric productivity shocks.

It is also possible to consider the impact of monetary shocks given the structure of the model under review, even though there is no explicit monetary sector in the model. We know that in response to any type of monetary shock, the equilibrium real wage rate does not change. If wages are pre-set at expected market-clearing levels, anything that enhances predictability of the aggregate price level must be a good thing. If the foreign price level is perfectly predictable, and internal monetary shocks are the dominant source of fluctuations, then a fixed exchange rate regime is clearly optimal.[3] If there are only domestic monetary shocks, wage rigidity has no welfare costs under fixed exchange rates, since the fixed nominal wage always turns out to clear the labour market ex post. However, monetary shocks are a two-edged sword. It could be argued, and I'm quite sure the Bank of Canada would want to agree, that the Bank is doing a better job of stabilizing prices (or inflation) than the Federal Reserve Bank or other foreign central banks. If this is the case, then flexible rates are preferable even when monetary shocks are the most important source of fluctuations.

Conclusions

I believe that understanding the true relative importance of different types of macroeconomic shocks is the key to determining the optimal exchange rate regime. We are almost there in terms of our ability to construct DGE models that capture the aspects of reality that are relevant to the analysis for a complex economy like Canada's. This paper takes a giant step in the right direction. I think that the structure of the model, except for the lack of a true monetary sector and a trade-off between labour and leisure, provides almost the right level of abstraction for meaningful welfare analyses.

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[2] Backus, Kehoe, and Kydland (1995) point out that most open economy DGE models predict a variance of the real exchange rate that is substantially below that in the data on industrialized countries.

[3] If we allow for phenomena like rational speculative bubbles in foreign exchange markets, the welfare costs of flexible rates could be considerably magnified.

This type of model should be used with sophisticated econometric analysis to pin down structural parameters and the variance-covariance matrix of the underlying shocks.

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Monetary Policy, Exchange Rate Flexibility, and Exchange Rate Pass-Through

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Michael B. Devereux

Introduction

This paper develops a dynamic general-equilibrium (DGE) model of a small open economy to investigate alternative monetary rules, differing primarily in the degree to which they allow for exchange rate flexibility. A central argument of the paper is that the nature of the trade-off between fixed and floating exchange rates may be quite different in mature industrial economies than in emerging-market economies. The critical distinction is the degree to which movements in the exchange rate pass through to domestic consumer prices. With very high exchange rate pass-through, all monetary rules face a significant trade-off between output (or consumption) volatility and the volatility of inflation. Policies that stabilize output require high exchange rate volatility, which implies high inflation volatility. But with limited or delayed pass-through, this trade-off is much less pronounced. A flexible exchange rate policy that stabilizes output can do so without high inflation volatility. We also argue that the best monetary policy rule in an open economy is one that stabilizes non-traded goods price inflation. Finally, we show that a policy of strict inflation targeting is much more desirable in an economy with limited pass-through.

> The pass-through of exchange rates to inflation was much higher in Mexico than in Canada, Australia, or New Zealand. And this has to do a lot with history, with credibility of monetary policies, and this is one of the big challenges that we

> are facing today in Mexico in the conduct of monetary policy. And we have to really build sufficient credibility so that this pass-through from exchange rate movements to inflation ceases to be such an automatic reaction.
>
> —Guillermo Ortiz, Governor, Central Bank of Mexico
> 24 June 1999

Since the Mexican and Asian crises, there has been a very public debate about the costs and benefits of floating exchange rates for emerging-market economies. Some writers argue that the main lesson to be derived from the crises of the 1990s is that exchange rates should be allowed to float freely (Woo, Sachs, and Schwab 2000; Chang and Velasco 1998; Obstfeld and Rogoff 1995a). Others dispute the benefits of floating exchange rates, since floating exchange rates may be associated with discretionary monetary policy and macroeconomic instability (Calvo 1999b); or exchange rate volatility might disrupt financial markets that exhibit "liability dollarization" (Eichengreen and Hausmann 1999); or floating exchange rates may be replaced with de facto exchange rate pegging (Calvo and Reinhart 2000), thus making an economy vulnerable to a currency crisis.

The aim of this paper is to identify the main trade-offs between policies that allow for exchange rate flexibility and those that try to target the exchange rate. Our model is a two-sector, small open economy, where nominal rigidities are present in the form of sticky non-traded goods prices. The economy is subject to a series of external shocks, to which it must adjust—whatever the exchange rate policy being followed.

A central argument of the paper is that the nature of the trade-off between fixed and floating exchange rates may be quite different in mature industrial economies like Canada or Australia and emerging-market economies such as Mexico, Brazil, or Malaysia. The critical difference between these examples is the degree to which movements in the exchange rate pass through to domestic consumer prices. As suggested by the Ortiz quotation, movements in exchange rates typically feed quickly into price levels in emerging-market economies, or at least do so a lot more quickly than in OECD economies. For stable, high-income economies, a wealth of recent evidence (see Engel 1999 for evidence and references) has established that consumer prices show very little short-run response to movements in exchange rates. For the case of the United Kingdom, Canada, Mexico, and Korea, Table 1 illustrates the results of a regression of monthly consumer price index (CPI) inflation rates on lagged exchange rate changes vis-à-vis the U.S. dollar. For Canada and the United Kingdom, the lagged exchange

Table 1
Monthly inflation rates and exchange rate changes

	Constant	Lagged ER change	S.E.E.	R^2
Canada	0.0167**	0.0458	0.001	0.001
	(7.75)	(0.71)		
U.K.	0.001**	0.005	0.0002	0.0004
	(6.53)	(0.74)		
Mexico	0.0056**	0.1125**	0.004	0.18
	(14.34)	(5.27)		
Korea	0.0017**	0.029**	0.0002	0.26
	(9.49)	(6.55)		

Notes: Dependent variable is monthly CPI inflation rate.
Sample 1990(1)–2000(7).
** = significant at 5 per cent.

rate change has no explanatory power, at the monthly frequency, for CPI inflation. But for Mexico and Korea, the coefficient on lagged exchange rate changes is highly significant. The pass-through for Mexico is over 10 per cent, but smaller for Korea. Thus, our working hypothesis is that exchange rate pass-through is very rapid for emerging markets, but slow for advanced economies.

How does this change the nature of the monetary policy-making problem? Much of the literature on monetary policy in open economies (Svensson 2000; Ball 1998, 2000) has been based on the premise that the rate of CPI inflation is instantaneously affected by movements in exchange rates. For policy-makers concerned about inflation, this represents both an opportunity and a constraint on optimal monetary policies. But, as suggested in the previous paragraph, this hypothesis is not wholly accurate, except for emerging-market economies.

Our methodology is to compare the properties of a series of different monetary rules in the face of exogenous external shocks to the small economy.[1] Two types of Taylor rules are introduced, one that partially targets the nominal exchange rate and one a standard Taylor rule. We also examine a rule that stabilizes the domestic rate of CPI inflation (strict inflation targeting) and a rule that pegs the exchange rate. Finally, we examine the properties of a rule that stabilizes the rate of non-traded goods inflation. This is the two-sector open economy analogue to the optimal monetary rule identified by Goodfriend and King (1997) in that it eliminates all variability in the real marginal cost for non-traded firms, and therefore attains the equilibrium of the hypothetical economy without nominal rigidities.

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[1] Monacelli (1999) has also contrasted monetary policy rules in an open economy with full pass-through to those with imperfect pass-through. Our model differs in a number of ways: we focus on a two-sector "dependent-economy" model, examine a wider range of shocks, and allow for a wider range of monetary policy rules, including fixed exchange rates. We also directly compare welfare across the different exchange rate regimes, as well as calibrate our model to the case of emerging-market economies.

The main result of the analysis is that the trade-off between exchange rate regimes (or monetary policy rules) may be quite different for an emerging-market economy with very high exchange rate pass-through than for an advanced economy with limited short-run exchange rate pass-through. In the emerging-market case, a flexible exchange rate rule (such as the Taylor rule or the rule that stabilizes non-traded inflation) will help to stabilize the real economy in the face of external shocks. By facilitating adjustment in both the real exchange rate and real interest rate, these rules can cushion the economy from the impact of external shocks. The markup-stabilization rule appears to be the best rule to achieve this result. But, to stabilize GDP and consumption, the rule has to allow a high volatility in the nominal exchange rate and, therefore, high inflation volatility. There is a clear trade-off between output/consumption volatility and inflation volatility. If the authorities are concerned with consumer price inflation[2] (over and above non-traded goods inflation), then the flexible exchange rate regime brings some costs as well as benefits. Moreover, the same logic implies that a policy of strict inflation targeting is quite undesirable in an open economy, since it effectively amounts to a requirement of fixing the exchange rate. It stabilizes inflation at the expense of a lot of output instability.

The situation is quite different when pass-through is limited. We model this process by assuming that foreign firms follow a practice of setting prices in domestic currency and only gradually adjust to exchange rate changes. In this environment, we find that there is no trade-off between output volatility and inflation volatility. In fact, a flexible exchange rate can deliver lower output variance and lower inflation variance than a fixed exchange rate regime. Of all the rules considered, the markup-stabilization rule minimizes the variance of output, consumption, and inflation.

The explanation of these results is easy to see. When exchange rate changes do not fully affect consumer prices, then external shocks that cause exchange rate movements have a smaller effect on internal relative prices facing households and a smaller effect on domestic inflation. Consequently, both inflation and the real economy tend to be stabilized. At the same time, since exchange rates still immediately affect interest rates (through uncovered interest rate parity (UIRP)), the monetary policy rule under flexible exchange rates can still use nominal exchange rates to help stabilize the economy. Thus, in effect, the exchange rate can be used without inflationary consequences. The conclusion is that the monetary policy problem is much more favourable in an economy with limited pass-through, and this tilts the balance strongly towards floating exchange rates.

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[2] In our model, there is really no reason why consumers should be concerned with CPI inflation if the inflation rate of non-traded goods is stabilized. Realistically, however, it is highly likely that central banks will be concerned more generally with CPI inflation.

A corollary of these findings is that a policy of strict inflation targeting is much less costly in an economy with limited pass-through, since inflation can be stabilized while still allowing for a considerable degree of nominal exchange rate volatility.

A general finding of the paper, in comparing monetary rules, is that the rule that stabilizes non-traded goods price inflation performs the best. It is a straightforward, coherent rule, and simply says that the authorities should not pay attention directly to the exchange rate or traded goods prices in setting interest rates.[3] There is an additional attractive feature of the rule. A Taylor-type rule in an open economy may be destabilizing in the presence of internal shocks to the monetary policy decision-making structure. If we thought of such shocks as related to credibility or risk-premium shocks, there might be a case for a currency board or a dollarization to eliminate this type of instability. But the rule that stabilizes non-traded goods price inflation also automatically neutralizes such internal monetary policy shocks. To the extent that such a rule can be made credible, it has an advantage over a pegged exchange rate, since it also helps to stabilize the economy in the face of external shocks.

Section 1 develops the basic model, which is a two-sector, small open dependent-economy model. The model is calibrated and simulations are reported in section 2. Section 3 discusses the difference between alternative monetary rules for the volatility of inflation, output, and other variables, and examines welfare comparisons across regimes. Conclusions follow.

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[3] There is a parallel between a non-traded goods inflation rule and the central bank practice of focusing on core inflation, excluding goods whose prices display high short-term volatility. To the extent that these goods, such as food and energy, are imported, the focus on non-traded goods inflation and core inflation may lead to similar results.

1 The Model

We will describe the model of a small open economy that will be used to compare alternative monetary policy rules. The structure is a standard two-sector dependent-economy model. Two goods are produced: a domestic non-traded good, and an export good, the price of which is fixed on world markets. This is probably the best representation of the macroeconomic environment of emerging-market economies. Although the real exchange rate is determined by domestic macroeconomic equilibrium, the economy has no international market power in traded goods.

A central aspect of the model is the presence of nominal rigidities. Price stickiness introduces a role for monetary policy and a non-trivial comparison between exchange rate regimes. But, unlike the standard analysis of price stickiness in closed-economy models (e.g., Goodfriend and King 1997, Rotemberg and Woodford 1998), in a small open economy, prices in the traded goods sector are determined by world prices. Non-traded goods prices are set in advance by domestic firms, however, and adjust only gradually to shocks.

There are three groups of actors in the economy: consumers, firms, and the monetary authority.

1.1 Consumers

The economy is populated by a continuum of consumer/households of measure unity. The representative consumer has preferences given by:

$$U = E_0 \sum_{t=0}^{\infty} \beta u(C_t, H_t, m_t), \tag{1}$$

where C_t is a composite consumption index, such that $C_t = C(C_{Nt}, C_{Mt})$, where C_{Nt} represents consumption of non-traded goods, and C_{Mt} is consumption of an imported foreign good. H_t is labour supply, and $m_t = M_t/P_t$ represents real balances, with M_t being nominal money balances and P_t the CPI. We will impose specific functional forms on the function $U(C, H, m)$. Let the functional form of u be given by:

$$u(C, H, m) = \frac{C^{1-\sigma}}{1-\sigma} - \eta\frac{H^{1+\psi}}{1+\psi} + \chi\frac{m^{1-\varepsilon}}{1-\varepsilon}.$$

In addition, if we let composite consumption take the form:

$$C_t = \left(a^{1/\rho}C_{Nt}^{1-1/\rho} + (1-a)^{1/\rho}C_{Mt}^{1-1/\rho}\right)^{\frac{\rho}{\rho-1}},$$

then the implied CPI is:

$$P = \left(aP_{Nt}^{1-\rho} + (1-a)P_{Mt}^{1-\rho}\right)^{\frac{1}{1-\rho}}.$$

Finally, assume that consumption is differentiated at the individual goods level, so that:

$$C_{jt} = \left(\int_0^1 C_{jt}(i)^{i-\lambda}di\right)^{1/(1-\lambda)},$$

where $\lambda > 1$, $j = H, M$.

Consumers are assumed not to face any capital-market imperfections.[4] Therefore, the consumer can borrow directly in terms of foreign currency at a given interest rate, i_{t+1}^*, for period t. Consumer revenue flows in any period come from their supply of labour to firms for wages W_t, transfers T_t, from government, profits from firms in the non-traded sector Π_t, return on capital that is rented to firms in each sector, domestic money, less their debt repayment from last period, D_t. They then obtain new loans from foreign capital markets and use these loans to consume, invest in new capital, and acquire new money balances. Their budget constraint is thus:

$$\begin{aligned} &P_tC_t + (1+i_t^*)S_tD_t + P_t(I_{Nt} + I_{Xt}) + M_t \\ &= W_tL_t + \Pi_t + S_tD_{t+1} + M_{t-1} + T_t + P_tR_{Nt}K_{Nt} + P_tR_{Xt}K_{Xt}. \qquad (2) \end{aligned}$$

Capital stocks in the export and non-traded sectors evolve according to:

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[4] Much of the recent post-crisis literature on emerging markets has stressed the imperfections and instability of capital markets. See, e.g., Cespedes, Chang, and Velasco (2000); Aghion, Bacchetta, and Banerjee (2000); Devereux and Lane (2000); Cook (2000); and others. But how much this should affect the monetary policy problem is open to debate. Cespedes, Chang, and Velasco and Devereux and Lane show that introducing collateral constraints on foreign-investment financing and a "currency mismatch" in balance sheets does not affect the qualitative conclusions with respect to optimal monetary policy in an otherwise conventional model of a small open economy (such as the model here). Cook, however, finds a different result, using an alternative specification.

$$K_{Xt+1} = \phi\left(\frac{I_{Tt}}{K_{Tt}}\right)K_{Xt} + (1-\delta)K_{Xt}, \tag{3}$$

$$K_{Nt+1} = \phi\left(\frac{I_{Nt}}{K_{Nt}}\right)K_{Nt} + (1-\delta)K_{Nt}, \tag{4}$$

where the function ϕ satisfies $\phi' > 0$, and $\phi'' < 0$. This reflects the presence of adjustment costs of investment. Under this specification, capital cannot move between sectors at any given time period, but capital in each sector adjusts over time.

The household will choose non-traded and imported goods consumption to minimize expenditure, conditional on total composite demand, C_t. Demand for non-traded and imported goods is then:

$$C_{Nt} = a\left(\frac{P_{Nt}}{P_t}\right)^{-\rho} C_t \qquad C_{Mt} = (1-a)\left(\frac{P_{Mt}}{P_t}\right)^{-\rho} C_t.$$

The consumer optimum can be characterized by the following conditions.

$$\frac{1}{(1+i^{*}_{t+1})} C_t^{-\sigma} = E_t\beta\frac{S_{t+1}}{S_t}\frac{P_t}{P_{t+1}} C_{t+1}^{-\sigma}. \tag{5}$$

$$\frac{W_t}{P_t} = \eta C_t^{\sigma} H_t^{\psi}. \tag{6}$$

$$\left(\frac{M_t}{P_t}\right)^{-\varepsilon} = \chi C_t^{-\sigma}(1 - E_t d^{h}_{t+1}). \tag{7}$$

$$\frac{C_t^{-\sigma}}{\varphi'(i_{Nt})} = E_t\beta C_{t+1}^{-\sigma}\left(R_{Nt+1} + \frac{(1-\delta+\varphi'(i_{Nt+1})i_{Nt+1})}{\varphi'(i_{Nt+1})}\right). \tag{8}$$

$$\frac{C_t^{-\sigma}}{\varphi'(i_{Tt})} = E_t\beta C_{t+1}^{-\sigma}\left(R_{Xt+1} + \frac{(1-\delta+\varphi'(i_{Tt+1})i_{Tt+1})}{\varphi'(i_{Tt+1})}\right). \tag{9}$$

Equation (5) represents the Euler equation for optimal consumption. Equation (6) is the labour-supply equation, while equation (7) gives the implicit money-demand function. Money demand depends on domestic nominal interest rates. The domestic nominal discount factor is defined as:

$$d^h_{t+1} = \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \frac{P_t}{P_{t+1}}. \tag{10}$$

Note that the combination of equations (5) and (10) gives the representation of UIRP for this model. Finally, conditions (8) and (9) describe the optimal investment choice for the household, where the consumer separately accumulates capital stock for use in the non-traded and traded goods sectors.

1.2 Production firms

Production is carried out by firms in the non-traded and export sectors. The sectors differ in their production technologies. The non-traded sector uses labour and specific capital to produce. An individual firm in the non-traded sector has technology:

$$Y_{Nit} = A_N K_{Nit}^{\alpha} L_{Nit}^{1-\alpha}, \tag{11}$$

where A_N is a productivity parameter.

Traded goods production uses both imported intermediate inputs, I_{Mt}, and domestic value added, V_t, to produce, using the technology:

$$Y_{Xt} = (\vartheta V_t^{1-1/\phi} + (1-\vartheta) I_{Mt}^{1-1/\phi})^{\phi/\phi-1}. \tag{12}$$

Domestic value added is obtained from capital and labour according to:

$$V_t = A_X K_{Xt}^{\gamma} L_{Xt}^{1-\gamma}. \tag{13}$$

Cost-minimizing behaviour then implies the following equations:

$$W_t = MC_{Nt}(1-\alpha)\frac{Y_{Nit}}{H_{Nit}}, \tag{14}$$

$$R_{Nt} = MC_{Nt}\alpha\frac{Y_{Nit}}{K_{Nt}}, \tag{15}$$

$$W_t = P_{Xt}(1-\gamma)\frac{V_t}{H_{Xt}}\vartheta\left(\frac{Y_{Xt}}{V_t}\right)^{\frac{1}{\phi}}, \tag{16}$$

$$R_{Xt} = P_{Xt}\gamma\frac{V_t}{K_{Xt}}\vartheta\left(\frac{Y_{Xt}}{V_t}\right)^{\frac{1}{\phi}}, \tag{17}$$

$$P_{1Mt} = P_{Xt}\gamma(1-\vartheta)\left(\frac{Y_{Xt}}{I_{Mt}}\right)^{\frac{1}{\phi}}, \tag{18}$$

where MC_{Nt} denotes the nominal marginal production cost for a firm in the non-traded sector (which is common across firms). Equations (14) and (16) describe the optimal employment choice for firms in each sector. Equations (15) and (17) describe the optimal choice of capital. Note that the price of the traded export good is P_{Xt}. Movements in this price, relative to P_{Mt} and P_{1Mt}, represent terms-of-trade fluctuations for the small economy. Finally, equation (18) represents the condition for the optimal choice of intermediate inputs.

1.3 Price-setting

Firms in the non-traded sector set prices in advance. Following the method of Calvo (1983) and Yun (1996), assume that firms face a probability $(1-\kappa)$ in every period of altering their price, independent of how long their price has been fixed. Following standard aggregation results, the non-traded goods price follows the partial-adjustment rule:

$$P_{Nt}^{1-\lambda} = (1-\kappa)\tilde{P}_{Nt}^{1-\lambda} + \kappa P_{Nt-1}^{1-\lambda}, \tag{19}$$

where $\tilde{P}_{Nt}$ represents the newly set price for a firm that does adjust its price at time t.

The evolution of $\tilde{P}_{Nt}$ is then governed by (the approximation):

$$\tilde{P}_{Nt} = (\Gamma - \beta\kappa)MC_{Nt} + E_t\beta\kappa\tilde{P}_{Nt+1}. \tag{20}$$

Taking a linear approximation of equations (17) and (18), assuming an initial steady state where the rate of change of P_{N_t} is constant, we can derive the familiar forward-looking inflation equation:

$$\pi_{Nt} = \lambda mcn_t + E_t\pi_{Nt+1}, \tag{21}$$

where mcn_t represents the log deviation of real marginal cost in the non-traded sector, MC_t/P_{Nt}, from its steady-state level (of unity). Equation (19) is analogous to the forward-looking inflation equation in Clarida, Galí, and Gertler (1999). The key difference here is that both marginal costs and inflation are specific to the non-tradable sector.

1.4 Monetary policy rules

Assume that the monetary authority uses a short-term interest rate as the monetary instrument. Given the interest rate, the money supply will be determined endogenously by the aggregate demand for money arising from the consumer sector (i.e., equation (5)). Thus, the analysis of monetary rules can ignore the money supply, since it is determined as a residual. It is important, however, that interest rate rules are set to ensure a unique price level and exchange rate and to avoid the issue of "real indeterminacy" that can arise under some interest rate rules in sticky-price models.[5] Under all calibrations of the model, as discussed below, a unique equilibrium is obtained.

The general form of the interest rate rule used may be written as:

$$(d_{t+1}^{h})^{-1} = \left(\frac{P_{Nt}}{P_{Nt-1}}\frac{1}{1+\bar{\pi}_n}\right)^{\mu_{\pi n}}\left(\frac{P_t}{P_{t-1}}\frac{1}{1+\bar{\pi}}\right)^{\mu_{\pi}}\left(\frac{Y_t}{\bar{Y}}\right)^{\mu_y}\left(\frac{S_t}{\bar{S}}\right)^{\mu_s}$$

$$(1+\bar{i})\exp(u_t), \tag{22}$$

where it is assumed that $\mu_{\pi n} \geq 0, \mu_{\pi} \geq 0, \mu_y \geq 0, \mu_s \geq 0$. The parameter $\mu_{\pi n}$ allows the monetary authority to control the inflation rate in the non-traded goods sector around a target rate of $\bar{\pi}_n$. The parameter μ_{π} governs the degree to which the CPI inflation rate is targeted around the desired target of $\bar{\pi}$. Then μ_y and μ_s control the degree to which interest rates attempt to control variations in aggregate output and the exchange rate, around their target levels of $\bar{Y}$ and $\bar{S}$, respectively. The term $\exp(u_t)$ represents a shock to the domestic monetary rule.

This function allows for a variety of monetary rules. When $\mu_{\pi} = \mu_y = \mu_s = 0$, and $\mu_{\pi_n} \to \infty$, the monetary authorities pursue a policy of strict inflation targeting in the non-traded goods sector. From equation (19), we see that this will ensure that the real markup is constant. Intuitively, if the monetary policy acts to ensure that there is never a need to adjust prices, then there are no consequences of price stickiness. This point has been made by Goodfriend and King (1997) and others. Therefore, this policy will replicate the real equilibrium of an economy with flexible prices.

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[5] See Woodford (2001) for conditions on interest rate rules required for uniqueness in the price level. Also see Clarida, Galí, and Gertler (1999).

When $\mu_{\pi_n} = \mu_s = 0$, the authority follows a form of Taylor rule, where interest rates are adjusted to respond to deviations of CPI inflation and aggregate output from some target levels. When $\mu_{\pi_n} = 0$, the authority follows a modified Taylor rule in which the exchange rate is targeted in addition to CPI inflation and output. When $\mu_{\pi_n} = \mu_y = \mu_s = 0$ and $\mu_\pi \to \infty$, the monetary authority pursues strict CPI inflation targeting. Finally, when $\mu_{\pi_n} = \mu_y = \mu_\pi = 0$ and $\mu_s \to \infty$, the authority follows a pegged exchange rate.

1.5 Optimal monetary policy

What objective function should the monetary authorities have in this economy? Speaking generally, the model has a natural welfare index: the expected utility of households in the small economy. An optimal monetary policy would be one that maximizes expected utility. But, recent literature on the analysis of monetary policy in sticky-price DGE models has developed a more direct approach to the formulation of monetary policy objective functions. Goodfriend and King point out that, leaving out issues related to the Friedman rule (or, equivalently, assuming positive nominal interest rates), an optimal monetary policy should stabilize the markup of prices over marginal costs (real marginal cost). This is explained as follows. The only way in which a sticky-price economy differs from a flexible-price economy is that the markup of price over marginal cost is variable. With flexible prices, firms would set a constant and time-invariant markup (because of the Constant Elasticity of Substitution utility function). A monetary rule that stabilizes the markup replicates the flexible-price economy. If the equilibrium of the flexible-price economy is Pareto-efficient, this must represent the optimal monetary rule. In fact, the flexible-price economy will not typically have an efficient equilibrium, because of the presence of monopolistic competitive pricing. But since the monetary policy rule cannot affect the average markup of price over marginal cost in any case (at least in the linearized version analyzed here), the best rule for monetary policy is to reduce the variance of the markup to zero, thereby replicating the flexible-price economy.

Subsequent literature refined this rule (Clarida, Galí, and Gertler 1999; Woodford 2001) by linking movements in the price-cost markup to deviations of output from its potential level or the level that it would attain in a flexible-price economy. Woodford shows that in an economy where price-setting is staggered, inflation generates an additional welfare loss, independent of the gap between output and potential output (i.e., the unexploited gains from trade due to sticky prices). This loss arises from the dispersion in relative goods prices, leading to an inefficient allocation of resources between sectors. In this framework, Woodford's analysis implies that expected utility may be approximated by a quadratic function of output deviations from potential output and inflation deviations from zero. Both Woodford and Clarida, Galí, and Gertler then point out that in the absence of direct shocks to the pricing equation, an optimal monetary policy would set inflation to zero. This would stabilize the markup of price over marginal cost, as suggested by Goodfriend and King, and simultaneously keep output at its potential level and reduce the dispersion of relative prices to zero.

In the present model, in the case of immediate pass-through from the exchange rate to imported goods prices (i.e., $\kappa^* = 0$), a monetary policy rule that ensured a constant price-cost markup for non-traded goods firms would replicate the equilibrium of a flexible-price economy. In this case, an appropriate welfare index would be a combination of output deviations from potential, and inflation in the non-traded goods sector. This could be achieved by zero inflation in non-traded goods prices. In the economy with slow pass-through of exchange rate changes, the situation is more complicated, because even without sticky prices in the non-traded goods sector, monetary rules can have real effects through their impact on exchange rates. This may lead the monetary authority to be more generally concerned with CPI inflation and nominal exchange rate variability. But derivation of a welfare objective for monetary policy along the lines of Woodford is quite complicated because of the presence of investment, the two-sector structure, and imperfect pass-through.

Rather than take a stand on the exact form of the monetary authority objective function, we consider the implications of alternative monetary regimes for volatility in the major macro aggregates, including output, consumption, and inflation volatility. In some cases, inferences may be made about desirable monetary policy regimes without precise knowledge of the weights that the authority puts on inflation versus output volatility in its loss function. We also provide a ranking of alternative policies using household expected utility.

1.6 Local currency pricing

The law of one price must hold for both export goods, so that:

$$P_{Xt} = S_t P^*_{Xt}. \tag{23}$$

For import goods, however, we allow for the possibility that there is some delay between movements in the exchange rate and the adjustment of imported goods prices. Note that this is still consistent with the constraint that the economy is small and without market power in the traded goods sector. The assumption is that foreign suppliers may choose to follow a pricing policy that stabilizes the prices of imports in terms of local currency. Domestic consumers, however, take the local currency price of imported goods as given.

Without loss of generality, we may assume that imported goods prices are adjusted in the same manner as are prices in the non-traded sector. That is, a measure $1 - \kappa^*$ of foreign firms adjust their prices in every period. Thus, the imported good price index for domestic consumers moves as:

$$P_{Mt}^{1-\lambda} = (1-\kappa^*)\tilde{P}_{Mt}^{1-\lambda} + \kappa^* P_{Mt-1}^{1-\lambda}, \tag{24}$$

where $\tilde{P}_{Mt}$ represents the newly set price for a foreign firm that does adjust its price at time t.

The evolution of $\tilde{P}_{Mt}$ is then governed by (the approximation):

$$\tilde{P}_{Mt} = (1-\beta\kappa^*)S_t P^*_{Mt} + E_t \beta\kappa^* \tilde{P}_{Mt+1}. \tag{25}$$

The interpretation of equation (26) is that the foreign firm wishes to achieve the same price in the home market as in the foreign market. But it may incur a lag in adjusting its price. The coefficient κ^* determines the delay in the pass-through of exchange rates to prices in the domestic market. Using the same approach as with equations (20) and (21), the familiar inflation equation can be derived:

$$\pi_{Mt} = \lambda(\hat{s}_t + \hat{p}^*_{Mt} - \hat{P}_{Mt}) + E_t \pi_{Mt+1}. \tag{26}$$

where π_{Mt} is the inflation rate in domestically denominated traded goods prices, $\hat{s}_t$ and $\hat{p}^*_{Mt}$, and represents the log deviation of the exchange rate and foreign traded goods prices from steady state.

1.7 Equilibrium

In each period, the non-traded goods market must clear. Thus, we have:

$$Y_{Nt} = a\left(\frac{P_{Nt}}{P_t}\right)^{-\rho}(C_t + I_{Nt} + I_{Xt}). \tag{27}$$

Equation (27) indicates that demand for non-traded goods comes from consumers, both for consumption and investment demand. In a similar manner, we may describe the evolution of the economy's net debt, D_t, as:

$$S_tD_{t+1} = S_tD_t(1 + i_t^*) - P_{Xt}Y_{Xt} + (1-a)\left(\frac{P_{Mt}}{P_t}\right)^{-\rho}$$

$$(c_t + I_{Nt} + I_{Xt}). \tag{28}$$

Labour market clearing for the household sector implies:

$$H_{Nt} + H_{Xt} = H_t. \tag{29}$$

Finally, to recover the nominal price of non-traded goods and imported goods, we use the conditions:

$$P_{Nt} = \pi_{Nt} + P_{Nt-1}, \tag{30}$$

$$P_{Mt} = \pi_{Mt} + P_{Mt-1}, \tag{31}$$

with the initial prices P_{N-1} and P_{M-1} being given.

The economy's equilibrium may be described as the sequence of functions given by:

$C(\theta_t)$, $H(\theta_t)$, $S(\theta_t)$, $d^h(\theta_t)$, $Y_N(\theta_t)$, $Y_X(\theta_t)$, $V_X(\theta_t)$, $H_N(\theta_t)$, $K_N(\theta_{t-1})$,

$H_X(\theta_t)$, $K_X(\theta_{t-1})$, $I_X(\theta_t)$, $I_N(\theta_t)$, $I_M(\theta_t)$, $R_{Nt}(\theta_t)$, $R_{Xt}(\theta_t)$,

$\pi_N(\theta_t)$, $\pi_{Tt}(\theta_t)$, $mcn(\theta_t)$, $D(\theta_t)$, $W(\theta_t)$, $P_M(\theta_t)$, $P_X(\theta_t)$, $M(\theta_t)$, and

$P_{Nt}(\theta_t)$.

Here, θ_t is the period t information set. This represents a system of 25 functions that correspond to the solutions of the 25 equations (3) to (18), (21), (22) (23), (26), and (27) to (31), given the CPI definition and the definition of the shock processes (discussed below).

The model is solved by linear approximation, using the Schur decomposition method of Klein (2000).

2 Calibration and Solution

We now derive a solution for the model through calibration and then simulation, using standard linear approximation techniques. The calibration parameter values are listed in Table 2. Most values are quite standard. Rather than calibrating to any single national data set, we choose a set of consensus parameter values that are generally applied to developing economies. In some instances, where there is no direct evidence, we use common parameter assumptions from the macro general-equilibrium literature.

It is assumed that the intertemporal elasticity of substitution in both consumption and real balances is 0.5. The consumption intertemporal elasticity is within the range of the literature, and the equality between the two elasticities ensures that the consumption elasticity of money demand equals unity, as estimated by Mankiw and Summers (1986). The elasticity of substitution between non-traded and imported goods in consumption is an important parameter on which there is little direct evidence. Following Stockman and Tesar (1995), we set this to unity. The elasticity of labour supply is also set to unity, following Christiano, Eichenbaum, and Evans (1997). In addition, the elasticity of substitution between varieties of goods determines the average price-cost markup in the non-traded sector. Since we have no direct evidence on markups for emerging-market economies, we follow standard estimates from the literature in setting a 10 per cent markup, so that $\lambda = 11$.

Assuming that the economy starts out in a steady state with zero consumption growth, the world interest rate must equal the rate of time preference. We set the world interest rate equal to 6 per cent annually, an approximate number used in the macro real business cycle literature; at the quarterly level, therefore, this implies a value of 0.985 for β.

The factor intensity parameters are important in determining the dynamics of the model. These types of parameters are typically calibrated in DGE models by identifying the employment share of GDP. But since it is quite likely that this share differs across sectors, it is necessary to obtain separate wage shares at the sectoral level. We follow Devereux and Cook (2000) in

Table 2
Calibration of model

Parameter	Value	Description
σ	2	Inverse of elasticity of substitution in consumption
ε	2	Inverse of elasticity of substitution in real balances
β	0.985	Discount factor (quarterly real interest rate is $\frac{(1-\beta)}{\beta}$)
ρ	1.0	Elasticity of substitution between non-traded goods and import goods in consumption
η	1.0	Coefficient on labour in utility
ψ	1.0	Elasticity of labour supply
γ	0.7	Share of capital in export sector
δ	0.025	Quarterly rate of capital depreciation (same across sectors)
α	0.3	Share of capital in non-traded sector
υ	0.5	Share of value added in export good production
ϕ	0.5	Elasticity of substitution between intermediate inputs and value added in export good production
λ	10	Elasticity of substitution between varieties (for both goods)
a	0.5	Share on non-traded goods in CPI
κ	0.75	Probability of non-traded firms price remaining unchanged
$-\frac{\phi''}{\phi'}\frac{I}{K}$	0.5	Elasticity of q with respect to I/K ratio (inversely related to investment adjustment cost)

assuming that the non-traded sector is more labour-intensive than the export sector. Specifically, we take the labour share in the non-traded sector to be 70 per cent of value added, while the labour share in the export sector is 30 per cent of value added.

In combination with the model's other parameters, a, which governs the share of non-traded goods in the CPI, determines the share of non-traded goods in GDP. Typically, this is significantly smaller for open developing economies than for OECD economies. Devereux and Cook (2000) and Devereux and Lane (2000), estimate, for Malaysia and Thailand, that the share of non-traded goods in total GDP is 55 per cent and 54 per cent, respectively. For Mexico, Schmitt-Grohe and Uribe (2000) estimate a share of 56 per cent. Roughly following these studies, we set a at 0.5 to imply a share of non-traded goods to GDP of 50 per cent. In addition, we set the share of imported materials in export production to be equal to that of value added, and we assume that the elasticity of substitution between value added and intermediate imports is 0.5.

To determine the degree of nominal rigidity in the model, the value κ, which governs the speed of price adjustment in non-traded goods, must be chosen. Again, in the absence of direct evidence on this, we follow the literature (e.g., Chari, Kehoe, and McGrattan 1998) and set $\kappa = 0.75$, so that prices completely adjust after approximately four quarters. As is standard practice, we set the adjustment cost of capital (elasticity of Tobin's q with respect to the investment-capital ratio) to imply a standard deviation of investment relative to GDP in a reasonable range.

The degree to which exchange rate and foreign price shocks are passed through to domestic imported goods prices is governed by the parameter κ^*. As discussed above, this is a difficult parameter to pin down empirically. Estimates of pass-through of exchange rate changes to imported goods prices tend to be different from the observed effects of exchange rate changes on more aggregated price indexes. For instance, Goldberg and Knetter (1997) estimate that the median rate of pass-through in the United States is 50 per cent for manufacturing industries. But other macro evidence for the United States suggests a virtual absence of any effects of exchange rate changes on domestic goods prices (Engel 1999). Similarly, the Engel and Rogers (1996) study suggests few short-run effects of exchange rate changes on relative goods prices between the United States and Canada. This suggests that there is a considerable degree of local-currency pricing in traded goods industries in OECD countries. Within the structure of the present model, this evidence would suggest that κ^* is positive—foreign exporting firms do not immediately adjust their prices to exchange rate changes. In the absence of very precise estimates of κ^*, we follow a rule of thumb in setting $\kappa^* = \kappa$ for our calibration of an advanced economy. The rationalization for this number is that it agrees with Engel's finding that for the United States and its major industrial trading partners, there is virtually no difference in the characteristics of the prices of traded and non-traded goods.

On the other hand, as suggested above, the pass-through from exchange rates to prices is likely to be much higher for emerging markets. Evidence from the Asian and Mexican crises indicates a rapid transmission of exchange rate depreciation to imported goods prices. Again, however, precise estimates of the extent of pass-through have not been obtained. To fix ideas, we make the extreme assumption that the pass-through is immediate for our calibrated emerging-market economy. Thus, we set $\kappa^* = 0$ for the emerging-market model. Therefore, the law of one price obtains at all times. Both foreign price shocks and exchange rate changes have immediate implications for local prices of imported goods.

2.1 Shocks

The model implies that the economy is exposed to three types of external shocks: (i) shocks to foreign prices, (ii) shocks to the foreign interest rate, and (iii) terms-of-trade shocks. The first and third shocks are obviously interrelated. Conceptually, however, there is a difference between balanced movements in the world price level and shocks to the relative price of the domestic country export good. We let price shocks be represented by equal shocks to all foreign prices, i.e., to P^*_{Mt}, and P^*_{Xt}, and P^*_{1Mt}. Terms-of-trade shocks are represented by shocks to:

$$\frac{P^*_{Xt}}{P^*_{Mt}} \text{ and } \frac{P^*_{Xt}}{P^*_{1Mt}}.$$

Since shocks to these last two variables have almost identical effects, we assume that they are equivalent. Thus, the consumer and producer import price indexes are assumed to be the same.

In section 2.2, we will measure the size of these shocks for a group of Asian countries. At present, we wish to give an intuitive account of the basic properties of the model when subjected to each external shock.

2.1.1 The impact of external shocks under alternative monetary regimes

We now illustrate the workings of the model in response to the different external shocks, under each monetary rule. The monetary rules are categorized in Table 3. The markup rule stabilizes the rate of inflation in non-traded goods, as discussed above. Two Taylor-type rules are also discussed. Finally, there is a strict CPI inflation-targeting rule and a pegged exchange rate rule.

2.2 Interest rate shocks

Figure 1 describes the response of the economy to a foreign interest rate shock when pass-through from exchange rates to imported goods prices is immediate. The shock represents a 100-basis-point rise in i^*_t, which is assumed to follow an AR(1) process with parameter 0.57. (The shocks are calibrated more directly below.)

As discussed in Devereux and Cook (2000), the response to a foreign interest rate shock is to generate both an internal and external reallocation of

Table 3
Monetary rules

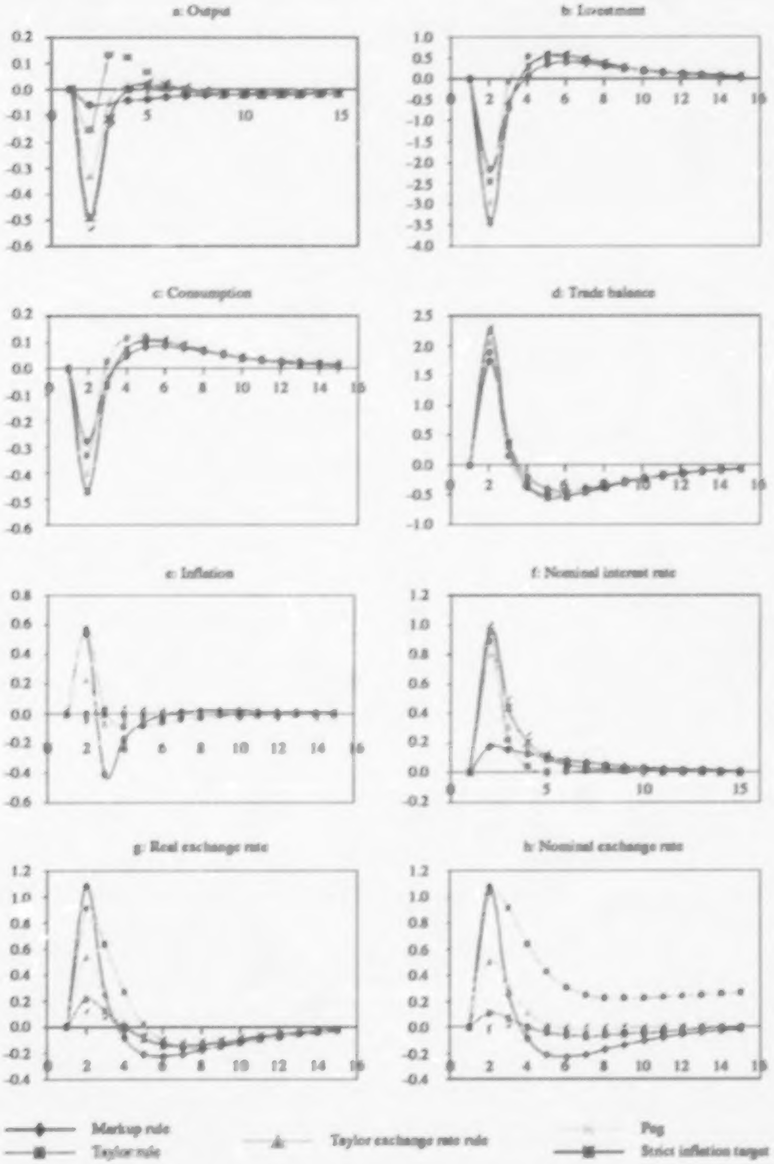
	$\mu_{\pi N}$	μ_{π}	μ_{y}	μ_{e}
Markup	$\to\infty$	0.0	0.0	0
Taylor	0	1.5	0.5	0
Taylor (e rate)	0	1.5	0.5	1
Peg	0	0.0	0.0	$\to\infty$
Price stability	0	$\to\infty$	0.0	0

resources in the economy. The interest rate disturbance reduces domestic absorption, generating a current account surplus. The fall in absorption also forces a real exchange rate depreciation, leading to a reallocation of factors from non-traded towards export good production. Thus, there is both an internal and external transfer. For all monetary policy rules, the same phenomenon is observed: absorption falls, the trade balance improves, and overall GDP falls.

But the magnitude of the response to an interest rate disturbance is affected quite strongly by the monetary rule. The response of the economy under a strict inflation target and a pegged exchange rate regime is almost the same. Domestic absorption falls by much more than under the markup rule or the two Taylor rules. Under the pegged exchange rate or the strict inflation target, the inflation rate is effectively stabilized. This means that the domestic real interest rate rises by the same magnitude as the exogenous foreign interest shock. However, the other three rules use the nominal exchange rate variability to cushion the real interest rate impact of the changes. The markup rule allows an immediate but transitory nominal exchange rate depreciation, which generates an expected appreciation. This dramatically limits the magnitude of the nominal interest rate rise. While the anticipated appreciation translates into an anticipated rate of CPI deflation, this is of a smaller magnitude than the anticipated appreciation itself. Figure 1g establishes that at the time of the shock, there is an expected real exchange rate appreciation, which reduces the real interest rate impact of the shock. But the expected real appreciation is much less for the fixed exchange rate rule and the price stability rule.

A clear implication of Figure 1, however, is that the monetary rules that provide stability in the real economy do so at the expense of inflation stability. The markup rule completely stabilizes the inflation rate in the non-traded goods sector, but requires high variability of the nominal exchange rate and therefore generates a highly volatile overall price level. There is a

Figure 1
Interest rate shock—full pass-through



trade-off between output stability and inflation stability. The trade-off can be seen most clearly by comparing the simple Taylor rule with the Taylor rule that includes an exchange rate response. The latter achieves a lower response of inflation, but at the expense of a higher first period fall in GDP.

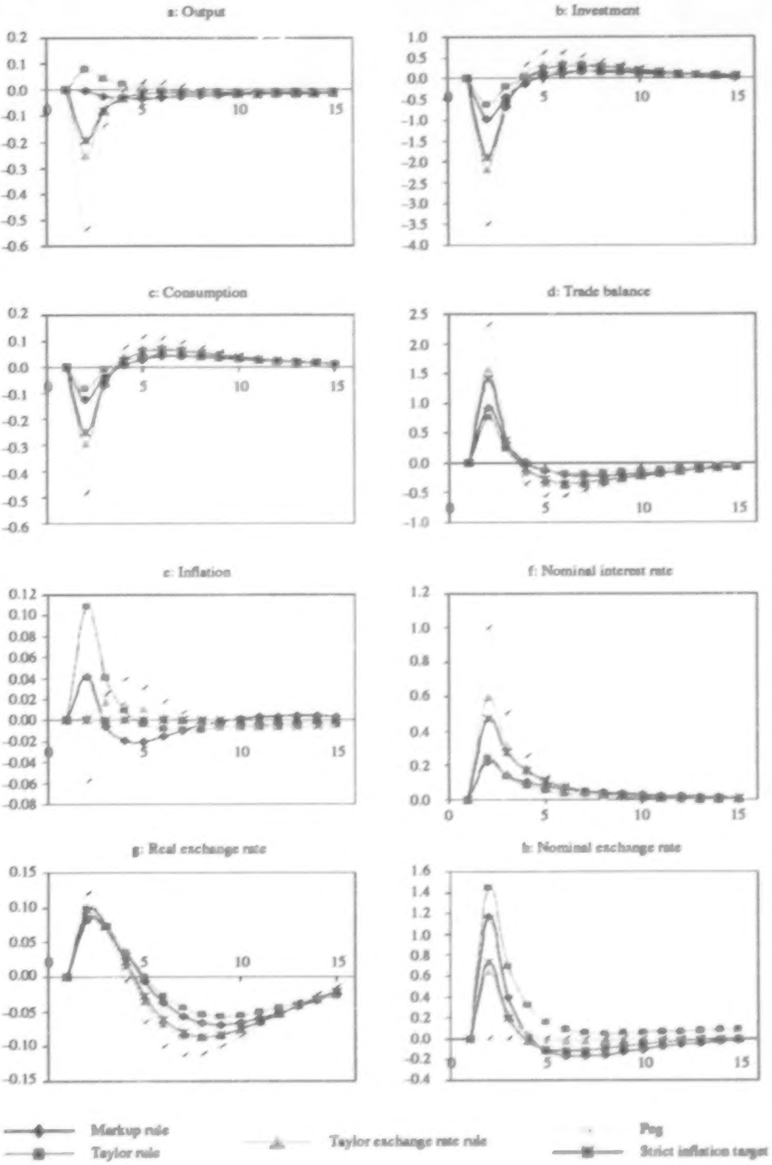
Figure 2 illustrates the case of delayed pass-through. With delayed pass-through, changes in exchange rates feed into the CPI only at the rate of overall price adjustment. Under the case of fixed exchange rates, the degree of pass-through is irrelevant, so the results are identical to those in Figure 2. For the markup rule and the two versions of the Taylor rule, however, the lower pass-through stabilizes the rate of inflation. Under the markup rule, the movement in inflation is only 10 per cent of the movement with immediate pass-through. This acts in two ways to stabilize the real economy. The muted impact on internal relative prices reduces the degree of expenditure switching and leads to a smaller contraction in non-traded goods production. But, the lower response of inflation now allows for a lower real interest rate response to the foreign interest rate shock. Under the markup rule, for instance, the expected rate of deflation in the period of the shock is much less than in the immediate pass-through model. This cushions the real interest rate response.

A further implication of the limited pass-through model is that it opens up a substantial difference between a price stability rule and the pegged exchange rate rule. The aggregate CPI can now be stabilized while still allowing significant movement in the nominal exchange rate. This implies, from Figure 2, that the goal of price stability is still consistently cushioning the nominal and real interest rate response to the shock. As a result, absorption and output under the price stability rule are much less variable than the pegged exchange rate rule.

Note that the flexible exchange rate monetary rules require very large nominal exchange rate variability. The nominal exchange rate response to the interest rate shock is higher than in the case of immediate pass-through. Thus, as observed in previous literature (Betts and Devereux 2000), limited pass-through tends to exacerbate exchange rate volatility. But it does so with consequences, since exchange rates do not immediately feed into CPI inflation.

The conclusion from this case is that in the presence of limited pass-through of exchange rate changes to import prices, there is no trade-off between output stability and inflation stability, at least in the response to interest rate shocks. A flexible exchange rate policy of the type analyzed here can

Figure 2
Interest rate shock—delayed pass-through



cushion the output response to an external interest rate shock without requiring more inflation instability. In fact, the (absolute) response of inflation is greater under a fixed exchange rate (which forces a deflation) than under the flexible exchange rate markup rule. Moreover, a rule following a goal of strict CPI price stability is still consistent with a stabilizing role for the nominal exchange rate.

2.3 Terms-of-trade shocks

Figures 3 and 4 describe the response of the model to terms-of-trade shocks. The shock is a 1 per cent fall in the terms of trade that persists with AR(1) coefficient 0.5. Figure 3 describes the model with immediate pass-through, while Figure 4 illustrates the case of delayed pass-through. We see that the general conclusions of the previous subsection apply. With immediate pass-through, the markup monetary rule stabilizes output and absorption, but does so by generating a high response of the exchange rate and of CPI inflation. The markup rule allows for a sharp, but transitory, nominal depreciation. The anticipated appreciation allows for a fall in the real and nominal interest rate. By contrast, the Taylor rule implies a persistent nominal depreciation. The nominal interest rate rises, and the real interest rate is unchanged. Again, the price stability rule and the pegged exchange rate rule are essentially the same.

With limited pass-through, Figure 4 shows that the real effects of the terms-of-trade shock are mitigated (for all rules except the pegged exchange rate). Given the very low inflation impact of the nominal depreciation, the Taylor rule becomes much more expansionary. In fact, all rules except the pegged exchange rate now generate a fall in the nominal interest rate. In terms of stabilizing output, consumption, and investment in response to the terms-of-trade deterioration, the Taylor rule and the price stability rules are essentially equivalent when there is limited pass-through.

Again, note that the nominal exchange rate responds by substantially more when there is limited pass-through, while inflation responds by substantially less. Thus, the trade-off between output stability and inflation stability disappears.

2.4 Price shocks

Figures 5 and 6 illustrate the impact of foreign price shocks. The price shock is modelled as a shock to the growth rate of foreign goods prices (both export and import), which leaves the terms of trade unchanged. Thus, letting

Figure 3
Terms-of-trade shock—full pass-through

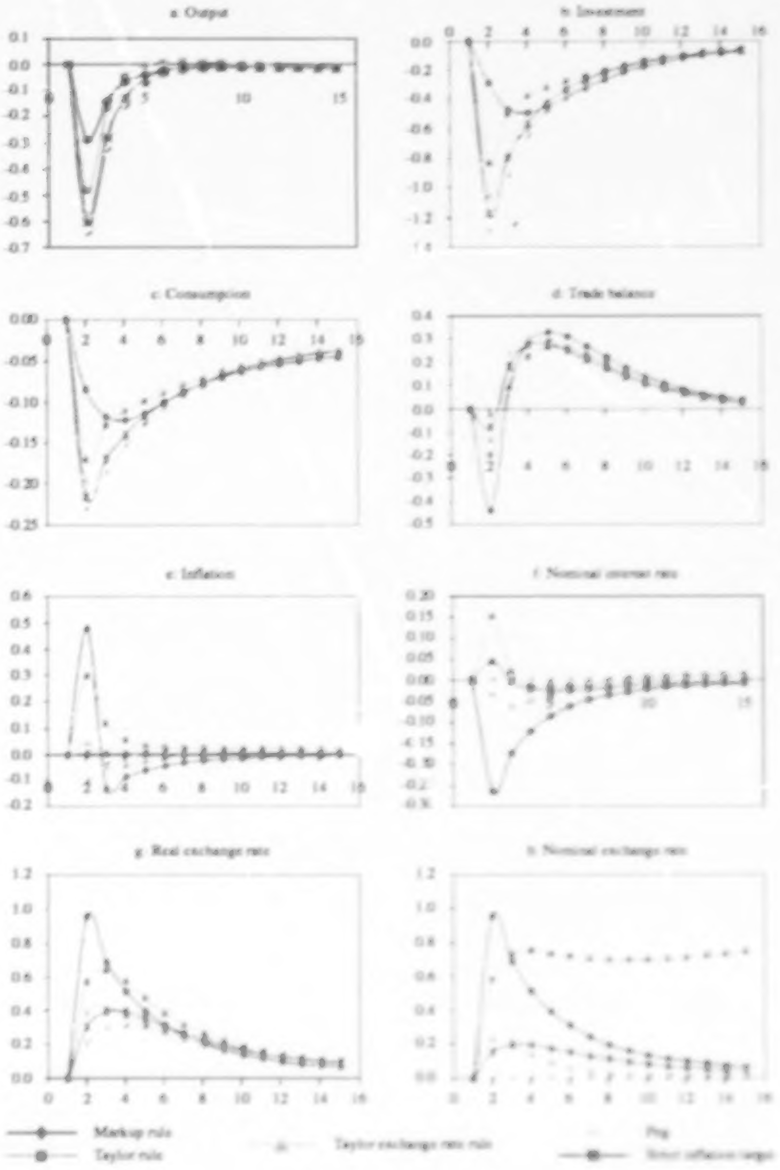


Figure 4
Terms-of-trade shock—delayed pass-through

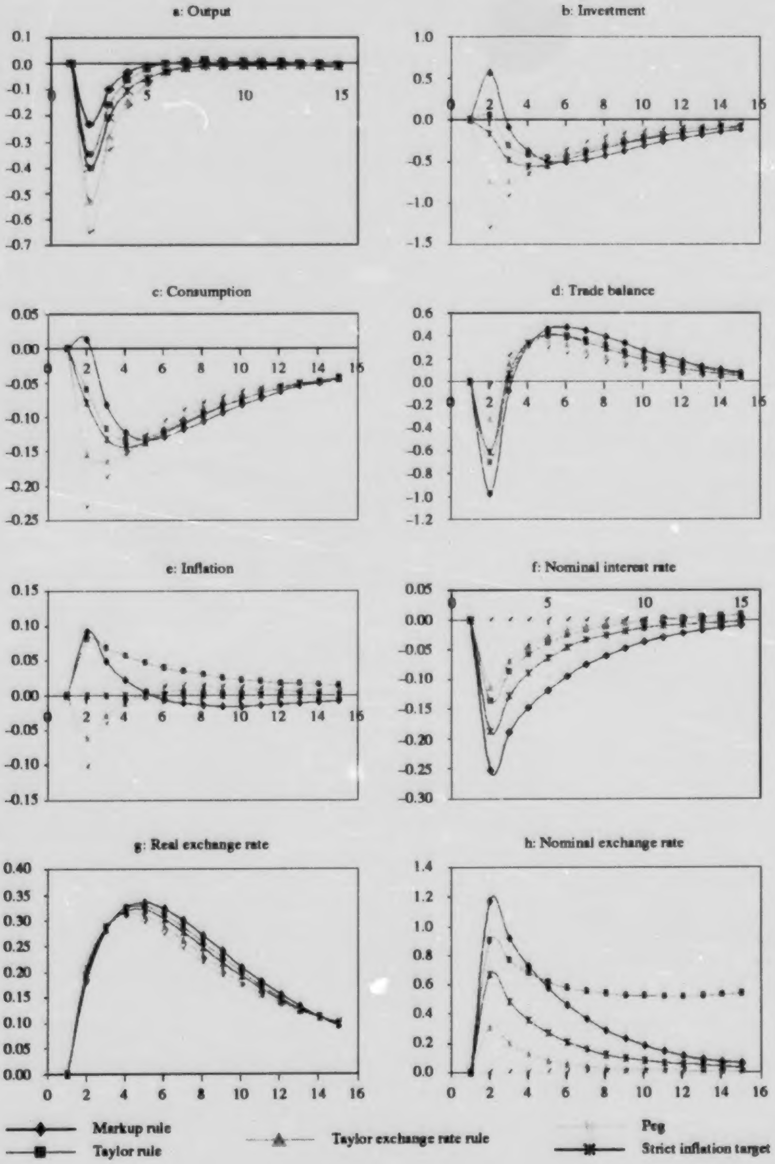


Figure 5
Foreign price shock—full pass-through

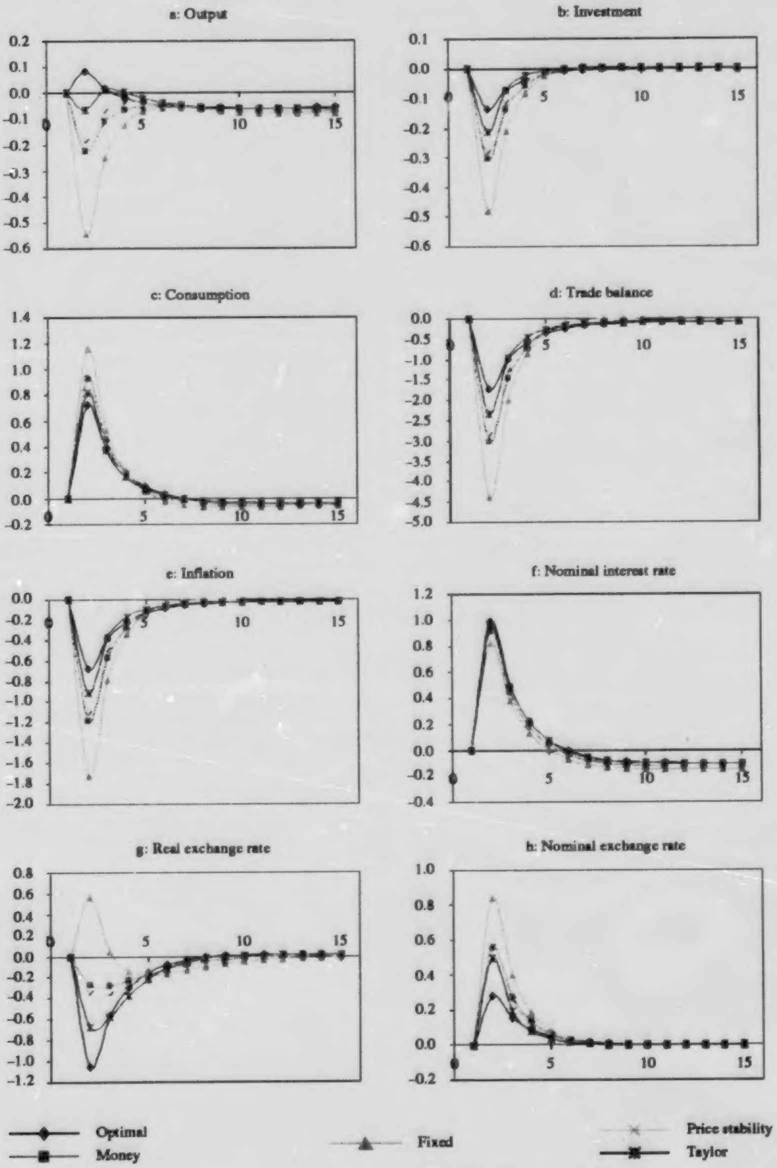
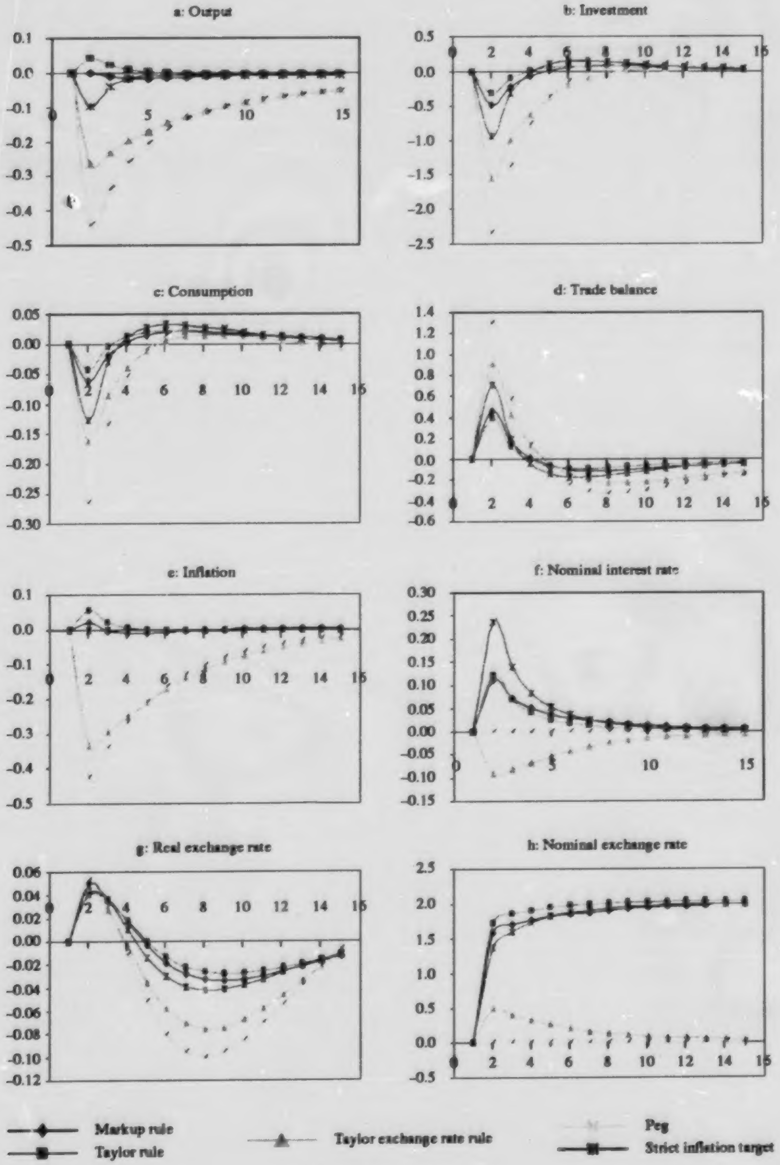


Figure 6
Foreign price shock—delayed pass-through



$\Delta P_t^* = \rho_1 \Delta P_{t-1}^* + \varepsilon_t$, Figure 5 illustrates the impact of a negative one-unit shock to ε_t with $\rho_1 = 0.5$. The effect of this shock can be thought of as a combination of a level shift in the foreign price and a rise in the foreign real interest rate.[6] For the monetary rules that do not concern themselves with the nominal exchange rate (markup, Taylor, and price stability rules), the only impact of the price shock is a real interest rate increase. These rules require a permanent increase in the nominal exchange rate to offset the fall in the foreign price level. But in terms of real effects, the results for these rules are the same as in Figures 1 and 2. For the pegged exchange rate and the Taylor rule with exchange rate response, however, the nominal exchange rate is either kept constant or forced to return to its initial position. Both rules, therefore, imply a domestic deflation to restore equilibrium, and both require a greater fall in output than the other rules. In the case of external price shocks, nominal exchange rate stability is no longer consistent with inflation stability. The absolute response of inflation is greatest under a pegged exchange rate.

Again, as before, the effect of delayed pass-through is to reduce the inflationary impact of the foreign prices shocks, while stabilizing the real economy. Even a pegged exchange rate achieves some inflation stability following a foreign price shock, when pass-through is limited, since the direct impact of the price shock is not immediately felt in consumer prices.

2.5 Internal shocks

A common criticism of floating exchange rates is that they may be associated with destabilizing internal shocks arising from domestic monetary policy uncertainty. In the standard Mundell-Fleming analysis, the presence of domestic nominal disturbances may tip the balance in favour of an exchange rate peg, since such shocks can be effectively eliminated by fixing the exchange rate. Recently, Calvo (1999a) has made the point that monetary policy instability in Latin America may offer a strong case for the desirability of currency boards or dollarization.

What does the model imply about the effects of internal shocks? We may model such shocks as disturbances to interest rates associated with the rule (22). Such disturbances can be entirely offset by an exchange rate peg, since the interest rate must adjust to continually equal the foreign interest rate. Under a Taylor rule, however, such monetary shocks affect real output and consumption.

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[6] To understand why the real interest rate must increase, imagine that the nominal exchange rate depreciated to keep the CPI constant in response to the declining path of foreign prices. This would leave the expected inflation rate unchanged, but would imply a positive expected rate of depreciation, increasing the nominal (and, therefore, real) interest rate.

But, by stabilizing non-traded goods prices, the markup rule also completely insulates the economy from internal shocks to the interest rate process! This is easy to see. Since the markup rule replicates the equilibrium of a flexible price economy, it supports an economy where monetary neutrality holds. Shocks to the nominal interest rate process do not affect real interest rates or any real magnitudes. Thus, the markup rule provides the same insulation from internal interest rate shocks as does a pegged exchange rate. But since the markup rule does a much better job of insulating the economy from external shocks, it is therefore much preferable to a peg, at least when the authority does not display an extreme dislike of inflation volatility (as in the case of full pass-through).

3 Quantitative Analysis of the Effects of Alternative Monetary Rules

In this section, we investigate quantitative and welfare implications of alternative monetary rules. This requires a stand on the magnitude and importance of the shocks. The approach taken is as follows. The interest rate shock is identified as the U.S. prime rate. This is a reasonably good measure of the foreign interest rate that is faced by emerging markets. Of course, there may be country-specific risk premiums affecting the borrowing costs of many emerging markets. Calvo (1999b) also suggests that these country risk premiums may themselves be related to the monetary regime—reflecting the degree of perceived international confidence in a country's monetary or fiscal regime. But there are significant difficulties in the measurement of these premiums. Consequently, we abstract from these. While it is likely that the analysis therefore underestimates the magnitude of interest rate shocks affecting emerging markets, this would not substantially affect the trade-off between fixed and floating exchange rates, since greater interest rate volatility would not only increase the stabilization benefits of floating exchange rates but increase the implied inflation variability as well.

Terms-of-trade shocks are measured as the ratio of export-to-import price deflators. We take an average terms of trade for Asia from the International Financial Statistics (IFS) of the IMF. Finally, we measure imported goods price shocks as the U.S. dollar price of import goods for Asia, again from the IFS.[7] The three-variable system—consisting of prime, U.S. dollar import prices, and terms of trade—is estimated as autoregressive. The results are contained in Table 4; they are used to calibrate the shock processes for the model.

Table 5 illustrates the difference between the various monetary rules for the volatility of GDP, the real exchange rate, consumption, investment, inflation, marginal cost, and the nominal exchange rate. The top section shows the results in the case of full pass-through, while the bottom panel shows the case of limited pass-through. With full pass-through, there is an inverse relationship between output/consumption volatility and inflation/nominal exchange rate volatility. The markup rule minimizes output and consumption volatility, but produces very high inflation and nominal exchange rate volatility. Output and consumption volatility is highest under a pegged exchange rate, but inflation volatility is very small under this rule. In addition, the difference between a peg and a strict inflation target is quite small.

The model also suggests that the quantitative effects of exchange rate flexibility may be substantial. Using a Taylor rule stabilizes output by about 60 per cent, and stabilizes consumption by about 18 per cent, relative to a fixed exchange rate. Stabilizing non-traded goods inflation reduces output volatility by two-thirds, and consumption volatility almost by half, although inflation volatility is doubled, relative to the pegged exchange rate.

When pass-through is lagged, the results are sharply different. The rule that stabilizes non-traded goods inflation now minimizes both output/consumption volatility and inflation volatility. Thus, on this dimension, the markup rule dominates a pegged exchange rate. Output and consumption volatility is lower for the three rules that do not target the exchange rate. There is also much less of a difference between the markup rule, the Taylor rule, and the price stability rule as regards overall output volatility.

As suggested in the previous section, Table 5 illustrates that, for the floating exchange rate rules, nominal exchange rate volatility is much higher with lagged pass-through. Nominal exchange rate volatility increases by 15 to 20 per cent in all cases. At the same time, the real exchange rate, measured as the domestic relative price of non-traded goods, is far less volatile, since

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[7] The following Asian countries are considered: Hong Kong, India, Indonesia, Korea, Pakistan, Papua New Guinea, Singapore, Sri Lanka, and Thailand.

Table 4
VAR estimates: Asia

Variable	Prime	Dlog (Pm)	Dlog (Px/Pm)
Prime (–1)	0.89	–0.002	0.0
	(31.1)	(–1.61)	(0.3)
Dlog (Pm(–1))	6.2	0.35	0.047
	(1.97)	(2.75)	(0.48)
Dlog (Px/Pm(–1))	5.63	0.13	–0.17
	(1.3)	0.01	(1.3)
C	0.88	0.017	–0.003
	(3.2)	(1.59)	(–0.3)

Residual covariance matrix	Prime	Dlog (pm)	Dlog (Px/Pm)
Prime	0.3	0.0027	0.0009
Dlog (Pm)	0.0027	0.00048	–0.00017
Dlog (Px/Pm)	0.001	–0.00017	0.00028

Table 5

		Markup	Taylor	Taylor (e rate)	Peg	Price stability
Full pass-through	σ_y^2	0.5	0.9	1.1	1.5	1.3
	σ_{rer}^2	3.9	2.8	1.9	1.6	1.2
	σ_c^2	1.5	1.9	2.0	2.3	2.2
	σ_π^2	3	2.3	1.1	1.5	0.0
	σ_s^2	4.9	4.5	1.8	0.0	2.8
	Expected utility	–55.6793	–55.6819	–55.6874	–55.689	–55.6871

		Markup	Taylor	Taylor (e rate)	Peg	Price stability
Limited pass-through	σ_y^2	0.6	0.7	1.0	1.5	0.7
	σ_{rer}^2	0.7	0.8	0.8	0.8	0.8
	σ_c^2	0.8	1.0	1.8	2.3	1.4
	σ_π^2	0.3	0.9	0.6	0.9	0.0
	σ_s^2	5.8	5.9	1.9	0.0	4.0
	Expected utility	–55.6771	–55.6796	–55.6832	–55.69	–55.6784

both non-traded prices and export good prices adjust much more slowly in response to all shocks.

Finally, Table 5 also includes welfare calculations across monetary rules. These are calculated by averaging repeated draws of utility over 100 quarters, evaluated at the consumer's discount factor.[8] In the case of full pass-through, the markup rule and the Taylor rule are almost equivalent, although the markup rule results in slightly higher utility. Both rules are clearly better, in utility terms, than the Taylor rule with exchange rate response, the pegged exchange rate rule, or the price stability rule. Again, with delayed pass-through, the markup rule leads (marginally) to highest utility. Utility is higher in this case for the markup rule, the Taylor rule, and the price stability rule. Also note that with delayed pass-through, the price stability rule gives utility almost the same as the markup and Taylor rules. In utility terms, therefore, a price stability rule does much better in a regime of limited pass-through.

These results confirm the general message of the paper: the fixed versus floating exchange rate trade-off is substantially different in an economy with high pass-through of exchange rates to traded goods prices than in an economy where pass-through is delayed. Given that pass-through is likely to be much faster in emerging markets, for reasons of policy credibility or small size, this makes the choice of fixed versus flexible exchange rates quite different for emerging markets than for advanced economies.

Conclusions

We have described the monetary policy trade-off between regimes that target the exchange rate and those that allow the exchange rate to adjust freely. Our main result is that the trade-off depends sharply on whether there is a high degree of pass-through from exchange rates to import good prices. A secondary result is that a policy of strict inflation targeting is much easier to implement in an economy with lagged pass-through, since the CPI can be stabilized without destabilizing the real economy. Finally, we outline a simple and efficient monetary policy rule for an open economy that is a natural extension of work with sticky prices in the closed-economy literature. This rule simply stabilizes the non-traded goods price level.

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[8] As in other literature (e.g., Obstfeld and Rogoff 1995b), the utility of real balances is ignored in this calculation. The utility estimates could be transformed into consumption-equivalent comparisons across the different policy regimes. But, as is well-known in this literature (e.g., Lucas 1987), the magnitude of welfare differences across different regimes in business cycle models is extremely small. Thus, we merely report the rankings of utility across regimes.

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Discussion

Kevin Moran

General Comments

I read the paper with great interest. And I think it contains enough to keep people at the Bank of Canada occupied for months—even years—with refining, detailing, and analyzing all relevant aspects of the model. A lot can be accomplished with this approach, and one hopes that work using this model as one of the basic set-ups will continue at the Bank.

It is a small open economy model, with non-traded and traded goods, price-taking at the traded-goods level, and sticky-price behaviour at the non-traded goods level. There are three types of external shocks: a world interest rate shock, a terms-of-trade shock, and a world price shock. The set-up could easily be expanded to accommodate domestic shocks (in money demand or technology).

The paper analyzes several possible monetary rules, arising from either an exchange rate pegging framework or from a flexible exchange rate spirit (Taylor rule, Taylor rule reacting to the exchange rate, inflation targeting, and targeting of inflation in non-traded goods). The paper stresses that we are not faced with a choice between fixed and flexible exchange rates, but rather with a choice between fixed exchange rates and the many possible policies compatible with flexible exchange rates.

The paper argues that if you have i) domestic price rigidity, ii) little or no pass-though from movements in the nominal exchange rate to domestic inflation, but iii) these movements still influence interest rates through uncovered interest parity (UIP), then monetary policy possesses some elements of a free lunch, because the nominal exchange rate movements can be used to cushion external shocks without causing inflation. If, on the other hand, pass-through from these exchange rate movements is immediate, the cushioning of external shocks comes at the expense of inflation, and the usual trade-off between variability in inflation and variability in output must be confronted.

What About Money?

Money is determined as a residual in the analysis and not even presented in the graphs: that hurts! More seriously, why would I want to see what happens to *M*? There are two reasons.

First, taking the model as a positive exercise (possibly by using some estimated rule from the data, as in Clarida, Galí, and Gertler 1998), I could check whether the model replicates the usual two stylized facts: money leads output, and money is negatively (contemporaneously) correlated with nominal interest rates.

Second, in a world where *M* is mostly endogenous (created by banks), we would have (real) money related to loans and to real activity. Could the fact that most of *M* appears in the economy as the counterpart to loans constrain monetary policy rules and thus modify the best reaction of monetary policy to shocks?

UIP and Exchange Rate Risk

A central feature of the model is that in reaction to outside shocks, monetary authorities can let the currency depreciate rather than modify domestic interest rates (the UIP hypothesis). The model, however, contains no puzzling behaviour from capital markets or exchange rate markets and probably contains very little exchange rate risk as defined by Engel (1999) (forward rates are more than likely very close to future spot rates). With regard to the conduct of monetary policy in practice, this may be an over-optimistic statement that introduces a bias against a policy of pegging the exchange rate.

One way to assess the extent of this potential problem is to add some noise to the nominal exchange rate. The chartists and fundamentalists of the foreign exchange market, as envisioned in this volume's Djoudad et al. model, could well provide that noise.

This may be an unfair criticism of the paper, since these problems affect the majority of open economy models I have seen. It would be interesting to know, however, the author's views on the significance of the failure of most models to generate significant amounts of exchange rate risk. Should this be an important avenue of research? Five years ago, it seemed that the observed high variability of the real and nominal exchange rate was incompatible with optimizing models. Now, thanks to the work of Devereux and others, it appears that this problem has, to a large extent, been resolved. Should exchange rate risk be next?

Small Open Economy

From my understanding, small open economy models with infinitely lived agents have problems with net foreign assets. These models do not lead to a unique determination of those assets in the steady state, and any level for those assets is consistent with a different steady state. This problem was among the factors that led the Bank of Canada to adopt an overlapping generations (OLG)-based framework as the basis of its main policy model. How, then, should this problem be taken care of?

If this constituted a problem, should it be reported in the simulations? What was the starting point—where net foreign assets are zero? And does it matter for the computations of expected utility? If an economy is, on average, in debt, decreases in world interest rates have positive income effects; whereas, if an economy is, on average, a net creditor, such decreases may carry negative income effects.

Welfare Measures and Unstable Rules

The paper states that the expected utility is not transformed into its consumption equivalent, because these numbers would be too small. However, the paper still goes on to comment on the rankings of rules according to the expected utility (alongside the more common ranking according to the variability of inflation and output) they imply. This step puzzles me. The facts are that, according to our utility functions, people are virtually indifferent to modest fluctuations and, therefore, smoothing out these fluctuations cannot significantly increase their welfare.

What can be done? If we think that fluctuations *do* matter, utility functions be damned, why not produce relative measures, i.e., measure the cost of a period of wild fluctuations (from 1929 to 1945, for example) and report our subsequent welfare measures in GDEUs (Great Depression-equivalent units).

Or maybe the role of good monetary policy rules is not to further smooth out fluctuations that are already fairly smooth, but rather to avoid bad outcomes, such as when the economy embarks on a path of self-fulfilling, explosive inflation (maybe as a result of the "expectations-trap" circuit described in

Christiano and Gust 2000). Including unstable rules in the analysis alongside the stable one analyzed here might produce more dramatic welfare results.

Exchange Rate Pass-Through and Fixed Prices

Devereux's paper makes the case that in some countries (Mexico is used as an example), the pass-through from exchange rates to prices is immediate; therefore, it includes simulations where κ^* is zero, while leaving κ constant. This means that Mexican importers immediately adjust their prices to changes in their costs, but Mexican producers of non-traded goods still do not. Is this a valid experiment? The data may say otherwise, but I would have thought that in Mexico, whether they come from exchange rate or domestic marginal costs, all cost shocks would be transferred rather quickly to prices so that the correct experiment may be to lower both κ and κ^*.

This leads us to the process of fixing prices. What exactly is it? Do κ and κ^* represent a structural/technological constraint? Or are they related to the monetary policy rule? Taylor (2000) argues that the pass-through from cost shocks to prices is related to monetary policy, and that good rules will be characterized by firms not passing through the cost increase, because they know it will be transitory. This leads me to once again suggest that the inclusion of bad (i.e., unstable) rules would be helpful because, in such a world, firms might immediately increase prices when shocks to the exchange rate occur, since they fear the depreciation will last a long time.

The type of pass-through occurring in an economy is an important factor in the determination of the best monetary policy rule. For this reason, there is an urgent need for reliable and comprehensive theories of price rigidity. The literature seems to have explored only a few of Blinder's (1994) 12 possible reasons why firms don't increase prices quickly. Perhaps some of the neglected theories are worth a second look.

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General Discussion

Serge Coulombe wondered about the regional impact of flexible exchange rate movements in response to terms-of-trade changes. Lawrence Schembri replied that the adjustment of the flexible nominal exchange rate still preserves the relative price change and, thus, the incentive for inter-industry adjustments, which may have a regional impact.

Simon van Norden noted that there may be first- as well as second-moment effects of a fluctuating nominal exchange rate. Could foreign exchange risk premiums, for example, alter the cost of capital for an open economy under flexible exchange rates? Schembri agreed that such an effect could exist, particularly for countries with high stocks of foreign debt. Michael Devereux argued that a credible monetary rule should not be expected to lead to a substantial risk premium. David Longworth, commenting on Michael Devereux's paper, noted that the non-optimizing literature tends to give similar results. He added that one of the justifications for using core inflation rates is specifically to ignore or to minimize the effects of pass-through, which may be easier to accomplish in more mature economies. Emerging economies, on the other hand, must deal with the price index people use—which is typically the CPI.

Charles Freedman questioned Devereux's assumption that pass-through is low in mature economies. He argued that this is conditional on the credibility of monetary policy, which affects the anchoring inflationary expectations. The important distinction, therefore, may be between more and less stable inflationary expectations, rather than between mature and emerging economies.

Kevin Clinton noted that there have been big reductions in inflation in some emerging economies. He wondered whether pass-through may have been correspondingly reduced and its extent overestimated by the data from the transition from high to low inflation periods.

Devereux agreed that the extent of pass-through is endogenous. According to his model, however, it should not matter how high the average rate of inflation is. If markets are competitive and there is pass-through, a large estimated pass-through coefficient should be obtained by the regression, whether or not there is high inflation. He also thought that the pass-through estimates were biased upwards by high inflation countries in the sample.

Michael Bordo suggested that in the past, monetary shocks were a large part of the story. Schembri, however, argued for a focus on commodity price shocks, since they are likely to be more relevant to the current environment of fluctuating commodity prices and stable central bank policies.

Session 2:
The Role of the Exchange Rate in Adjustment and Integration

Shocks Affecting Canada and the United States and the Flexible Exchange Rate's Contribution to Macroeconomic Adjustment

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*Ramdane Djoudad, Céline Gauthier, and Pierre St-Amant**

Introduction

Several recent studies have used structural vector-autoregression (VAR) models to analyze the determination of the Canada-U.S. exchange rate. Clarida and Galí (1994), for example, use a model of the Mundell-Fleming-Dornbusch type to identify supply shocks, real demand shocks, and monetary shocks in a VAR formulation including the real production differential, the real exchange rate, and the consumer price differential. The authors find that real demand shocks explain the bulk of the variation in the Canada-U.S. exchange rate for all time horizons.

In an examination of whether Canada and the United States constitute an optimal currency area,[1] Dupasquier, Lalonde, and St-Amant (1997) use VAR models including real production, inflation rates, and interest rates (in levels rather than in differences) to identify real and monetary supply and

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[1] Bayoumi and Eichengreen (1993); Racette, Raynauld, and Lalonde (1993); DeSerres and Lalonde (1994); and Lalonde and St-Amant (1995) also use structural VARs to determine whether North America constitutes an optimal currency area.

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demand shocks. Like Clarida and Galí, they find that real demand shocks account for most of the variation in the Canada-U.S. exchange rate. They further conclude that exchange rate flexibility promotes macroeconomic adjustment. This conclusion follows from the fact that the reaction functions they estimate imply that real exchange rate adjustments to various shocks are primarily transmitted over changes in nominal exchange rates rather than over changes in the relative price levels of two countries. In a fixed exchange rate regime, this realignment must occur over price-differential adjustments, creating disequilibrium in both labour and goods and services markets, assuming the standard macroeconomic framework with price rigidity.[3]

Another group of researchers emphasize commodity prices (energy and non-energy) as explanatory factors in the evolution of the real Canada-U.S. exchange rate. In particular, Amano and van Norden (1993) conclude that one can explain variations in this rate using a model with a cointegrating relationship between the exchange rate and commodity prices. McCallum (1999) and Djoudad and Tessier (2000) arrive at the same conclusion using somewhat different models. Murray, Zelmer, and Antia (2000) argue that these results support flexible exchange rate regimes, since they reflect the influence of fundamental factors rather than speculative bubbles.

These studies raise at least two questions. First, what type of shock dominates when commodities are added to the factors identified by Clarida and Galí? Second, can we always conclude, as do Dupasquier, Lalonde, and St-Amant, that the nominal exchange rate's reaction facilitates macroeconomic adjustment to shocks with asymmetric effects on Canada and the United States when commodity prices are included in the estimated models?

To answer these questions, we incorporate the variables used by Amano and van Norden into the structural VAR model of Clarida and Galí. Contrary to our expectations, our tests show little empirical support over the sample period for the cointegrating relationship identified by Amano and

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[2] Rose (1995) evaluates the contribution of the exchange rate to macroeconomic adjustment on the basis of models, using panel data from several countries. He concludes that there is no empirical evidence to support the claim that flexible exchange rates promote this adjustment. Osakwe and Schembri (1999) compare estimates of the conditional variance in Mexican real GDP under the historical regime of a managed float and under a hypothetical flexible exchange rate regime approximated by an adjusted parallel market rate. They conclude that fluctuations in real GDP would have been reduced had Mexico's exchange rate floated since the 1970s.

[3] It is possible that in a fixed exchange rate regime or in a monetary union, agents adjust their behaviour so that prices become less rigid. However, we are not aware of any study having concluded that adopting a fixed exchange rate or joining a monetary union has, in fact, engendered any significant changes along these lines.

van Norden. Nonetheless, we consider two scenarios—with and without cointegration—for two reasons. First, the capacity of the tests to distinguish between the presence and absence of cointegration is uncertain. Second, several authors have concluded that the assumption of a cointegrating relationship is valid. Our reference model excludes cointegration between the variables, but the inclusion of the broader information set makes it more compatible with tests for cointegration. Our alternative scenario uses the approach proposed by King et al. (1991) to model a cointegrating relationship between commodity prices and the real exchange rate.

Our models allow us to re-examine the relative contribution of various shocks in explaining variations in the real Canada-U.S. exchange rate. Moreover, we are able to evaluate the robustness of the results obtained by Dupasquier, Lalonde, and St-Amant, that flexible exchange rates promote macroeconomic adjustment.[4]

In addition, our models enable us to address several other questions. For example, they allow us to estimate the relative contribution of nominal shocks to variations in the real exchange rate. Since the models also include the real Canada-U.S. GDP differential, we are able to isolate its determinants as well.

In section 1 of this paper, we describe the approaches recommended by Clarida and Galí and Amano and van Norden. In section 2, we define and analyze our data. We explain our methodological approach in section 3 and our results in section 4. The final section concludes and suggests directions for further research.

1 Clarida and Galí's Approach and the Bank of Canada's Exchange Rate Determination Model

1.1 Clarida and Galí

To identify different types of shocks, Clarida and Galí (1994) use a theoretical two-country model of the Mundell-Fleming-Dornbusch type to construct a VAR specification with the following variables: the real GDP differential, the real exchange rate computed using consumer price indexes (CPIs), and CPI differentials. They demonstrate that the theoretical model can be arranged to show that, in long-term equilibrium, only supply shocks have an impact on the relative real GDP levels of the two countries, and that only real supply and demand shocks affect the level of the real exchange rate. These predictions of the theoretical model ensure identification of VAR models estimated for various country pairs.

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[4] Our work can also be considered as a response to Raynauld's (1997) comments on the paper by Dupasquier, Lalonde, and St-Amant. Raynauld emphasized that it would be of interest to explicitly account for commodity prices in the estimation of these models.

For each country pair considered, the models thus constructed present the first difference of the real GDP differential, the real exchange rate, and the CPI differential as responding to three types of structural shocks: supply shocks, ε^s; real demand shocks, ε^d; and monetary shocks, ε^m. Wold's decomposition theorem allows us to write the structural model in the following form (the constant has been omitted for simplification):

$$x_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + \ldots = \sum_{i=0}^{\infty} A_i\varepsilon_{t-i} = A(L)\varepsilon_t, \tag{1}$$

$$\text{where } \varepsilon_t = \begin{bmatrix} \varepsilon_t^s \\ \varepsilon_t^d \\ \varepsilon_t^m \end{bmatrix} \text{ and } x_t = \begin{bmatrix} \Delta y \\ \Delta rer \\ \Delta p \end{bmatrix}.$$

y represents the differential of real GDP in logs, rer the real exchange rate, and p the differential of the price level in logs. To simplify, the variance of the structural shocks is normalized to $E(\varepsilon_t\varepsilon_t') = I$, the identity matrix.

The following autoregressive vector is estimated for each pair of countries considered:

$$x_t = \Pi_1 x_{t-1} + \ldots + \Pi_q x_{t-q} + e_t, \tag{2}$$

where e_t is an estimated vector of residuals, q is the number of lags, and $E(e_te_t') = \Sigma$. This process is then inverted to yield the following moving-average representation:

$$x_t = e_t + C_1 e_{t-1} + \ldots = \sum_{i=0}^{\infty} C_i e_{t-i} = C(L)e_t. \tag{3}$$

The residuals of the reduced form are related to those of the structural model by:

$$e_t = A_0\varepsilon_t. \tag{4}$$

Equations (1), (3), and (4) can be solved to show that the matrix of long-term effects of the reduced form, $C(1)$, is related to the matrix of long-term effects of the structural form, $A(1)$, as follows:

$$A(1) = C(1)A_0. \tag{5}$$

To complete identification of the system, Clarida and Galí impose three restrictions on the matrix $A(1)$, reflecting the predictions of their theoretical model, yielding:

$$A(1) = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix}. \tag{6}$$

The first, second, and third columns of the matrix $A(1)$ represent the impact of supply shocks, demand shocks, and monetary shocks, respectively, on the real GDP differential (first row), the real exchange rate (second row), and the price-level differential (third row). The zeros in the first row indicate that real demand shocks and monetary shocks do not have a long-term impact on the GDP differential. The zero in the second row of $A(1)$ indicates that monetary shocks do not have a long-term impact on the real exchange rate.

The following predictions also follow from Clarida and Galí's theoretical model, when prices are assumed rigid in the short term but flexible in the long term.

- In the short and long term, the currency of a country affected by a positive supply shock depreciates in real terms.[5] In the short term, it depreciates in real terms subsequent to a monetary shock, and it appreciates in the short and long term in response to a positive real demand shock.
- The CPI of a country affected by a positive real demand or monetary shock progressively rises relative to that of the other country, but it declines subsequent to a positive supply shock.
- A supply shock, a real demand shock, or a monetary shock in a given country induces a short-term increase in production relative to the other country.

The empirical results obtained by Clarida and Galí correspond to their theoretical expectations. In the case of Canada and the United States, one of their conclusions is that variations in the exchange rate are dominated by real demand shocks.[6] They also find that supply shocks account for the largest share of the variance in the real GDP differential between the two countries. We re-evaluate these conclusions using richer models.

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[5] Conversely, the Balassa (1964) and Samuelson (1964) model predicts that, under certain assumptions, a positive supply shock will result in a currency appreciation.

1.2 A model of exchange rate determination used by the Bank of Canada

Some economists at the Bank of Canada use a model of exchange rate determination derived from the work of Amano and van Norden (1993). This model is written:

$$\Delta \ln(rer)_t = \alpha(\ln(rer)_{t-1} - \beta_0 - \beta_c c_{t-1} - \beta_o o_{t-1}) + \Upsilon r_{t-1} + \varepsilon_t, \qquad (7)$$

where the variables o and c, respectively, represent the price of energy and the price of non-energy commodities expressed in U.S. dollars and are deflated using the implicit GDP index for the United States. The variables in parentheses constitute a cointegrating relationship.[7] Actions of Canadian and U.S. monetary authorities are incorporated via r, the short-term Canada-U.S. interest rate differential.

Equation (7), which explains the principal fluctuations in the Canada-U.S. exchange rate, remained stable throughout the 1990s.[8] McCallum (1999) and Djoudad and Tessier (2000) include further variables in the models of Canada-U.S. exchange rate determination they estimate. However, at the centre of their models, we also find a long-term relationship between the real exchange rate, the price of energy, and the price of non-energy commodities.

2 The Data

2.1 Definitions and sources

We simultaneously incorporate the variables retained by Clarida and Galí and those in the exchange rate determination model represented by equation (7). We consider the following series:

- the Canada-U.S. real GDP differential in logs, y_t.
- the Canada-U.S. real CPI differential in logs, p_t.

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[6] The U.K.-U.S. country pair is the only other one for which they find this dominance of real demand shocks. Rogers (1999) re-evaluates that conclusion for the U.K.-U.S. pair using models that incorporate more variables. His approach is very different from the one we use here (accounting for neither commodity prices nor cointegrating relationships).

[7] The cointegrating relationship doesn't hold when no distinction is made between the price of energy and that of non-energy commodities.

[8] A recent evaluation can be found in Djoudad and Tessier (2000).

- the real exchange rate computed using the two countries' CPIs, rer_t. An increase in this series implies that fewer Canadian dollars are required to buy one U.S. dollar.
- the short-term interest rate differential, which we measure as the gap between the Canadian overnight rate and the federal funds rate, r_t.
- price indexes for non-energy commodities, c_t, and for energy, o_t. These series are expressed in U.S. dollars and deflated using the implicit GDP index for the United States.

The real Canadian GDP, the Canadian implicit GDP index, the federal funds rate, and commodity price indexes were provided by Statistics Canada. OECD data yielded the CPIs for the two countries. The implicit GDP deflator and real GDP for the United States were obtained from Data Research Incorporated (DRI). The overnight-rate series were from the Bank of Canada. The nominal exchange rate data were provided by the International Monetary Fund.

Our data are quarterly and cover the period subsequent to the collapse of the Bretton Woods system: from the first quarter of 1973 until the fourth quarter of 1999.

The above-mentioned series are reproduced in levels in Appendix 1.

2.2 Unit-root tests

Table A2.1 (Appendix 2) contains the results of several tests for a unit root applied to various series. These tests clearly indicate that the price of energy, the CPI differential, and the real exchange rate are non-stationary.[9] Most tests indicate that the price of non-energy commodities and the real GDP differential are non-stationary, but that the interest rate differential is stationary. We incorporate the corresponding assumptions into our model. Clarida and Galí and the exchange rate determination model of the Bank of Canada make the same assumptions.

2.3 Tests for cointegration

Johansen's (1991) tests for cointegration applied to the system $\{c, o, y, e, p, \Sigma r\}$ are presented in Table 1. We include the interest rate differentials (Σr) cumulatively rather than in levels, because this variable is stationary in levels. Note, however, that this variable is not significant in the

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[9] Some authors have concluded that the real exchange rate is stationary when considered over a very long time period. However, Engel (1996) shows that this result does not hold when certain biases in the tests are accounted for.

Table 1
Tests for cointegration

	λ-max test			Trace test		
H_0	Stat.	Corrected stat.[a]	90% critical value	Stat.	Corrected stat.	90% critical value
$p = 0$	45.90	29.04	37.45	141.34	89.42	97.18
$p \leq 1$	33.99	21.51	31.66	95.45	60.38	71.86
$p \leq 2$	25.07	15.86	25.56	61.45	38.88	49.65
$p \leq 3$	14.53	9.19	19.77	36.39	23.02	32.00
$p \leq 4$	12.12	7.67	13.75	21.86	13.83	17.85
$p \leq 5$	9.73	6.16	7.53	9.73	6.16	7.53

a. Here we have applied a small-sample correction by replacing T with $T-nm$, where T is the number of observations, n the number of variables, and m the number of lags. For more information, see Reinsel and Ahn (1988).

postulated cointegrating vector and thus only comes into play in levels (as opposed to cumulatively) in the estimated models. Moreover, omitting this variable does not change the results of the tests for cointegration on a qualitative level.

The number of lags, five, was determined by applying a likelihood-ratio test to an approach in which the generality of the model was progressively reduced. The critical values of the tests for cointegration were obtained from Osterwald-Lenum (1992).

We cannot reject the presence of two cointegrating vectors on the basis of the uncorrected λ-max test. Nonetheless, we conclude that all the variables are stationary on the basis of the uncorrected trace test. We reject this scenario, since it is incompatible with the results of our unit-root tests. Tests corrected to account for small-sample bias, on the other hand, allow us to reject any cointegration.[10] Since these tests are designed to be most reliable with small samples, results supporting cointegration are weak. Since the strength of these tests remains unknown, we also consider a scenario with cointegration. Considering the results of our tests for cointegration, however, we make the case of no cointegration our reference scenario.

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[10] We performed a variety of robustness tests. For example, we tested for cointegration using models containing one or two more or fewer lags, and on time series beginning a little earlier or a little later than the sample period of the reference scenario. In the majority of cases, we were unable to reject the assumption of non-cointegration on the basis of corrected tests. We repeated these tests using only the variables included in equation (7). Again, in the vast majority of scenarios, we were not able to reject the assumption of non-cointegration. Consequently, this result does not seem to depend on the fact that our model incorporated more variables than that of Amano and van Norden (1993).

A rolling-regression-type stability test applied to the cointegrating vectors identified using the uncorrected λ-max reveals that the first vector is unstable. We cannot reject the null hypothesis that the coefficients of the following variables in the retained cointegrating vector are zero: price differential, real GDP differential, and cumulative interest rate differential (type-one risk = 0.1124). The restricted vector can thus be expressed as follows when we normalize the cointegrating relationship on the exchange rate:

$$rer_t = 0.403 - 0.057o_t + 0.385c_t. \tag{8}$$

Consequently, it is with some difficulty that we identify the cointegrating vector included in the exchange rate equation used by the Bank of Canada.[11] This is the vector we integrate into the model for the scenario with cointegration.[12]

3 Our Methodology

3.1 Model with commodity prices but without cointegration

The VAR model includes the price of energy, the price of non-energy commodities, the real GDP differential, the real exchange rate, the CPI differential, and the interest rate differential. Thus, we assume a structural model responsive to six types of shocks: energy-price shocks, ε^o; non-energy commodity-price shocks, ε^c; supply shocks, ε^s; real demand shocks, ε^d; monetary shocks, ε^m; and transitory shocks, ε^t (shocks having no permanent impact on any of the variables except the cumulative interest rate). These shocks, the first difference of the variables considered in the estimated stationary VAR, and the postulated matrix $A(1)$, can be written as follows:

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[11] The coefficients generated by that vector have the same sign and are of the same order of magnitude as those obtained from models with fewer variables.

[12] Nonetheless, we believe that in future work it would be worthwhile to undertake a more detailed examination of the other cointegrating vector.

$$\varepsilon_t = \begin{bmatrix} \varepsilon_t^o \\ \varepsilon_t^c \\ \varepsilon_t^s \\ \varepsilon_t^d \\ \varepsilon_t^m \\ \varepsilon_t^t \end{bmatrix}, x_t = \begin{bmatrix} \Delta o \\ \Delta c \\ \Delta y \\ \Delta rer \\ \Delta p \\ \Delta r \end{bmatrix}, A(1) = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{bmatrix}.$$

It is worth noting that, as in Clarida and Galí, the identification restrictions pertain to the levels of the variables. We assume, therefore, that no shock, except a shock to the energy price, can have an impact on the energy price in the long term (the five zeros in the first row of $A(1)$). We further assume that, in the long run, shocks to the price of energy are the only ones to affect the price of non-energy commodities. We justify this ordering of o relative to c by the fact that energy is an important input into the production of many commodities, and may thus affect their long-term price. Nonetheless, we test the sensitivity of our results with respect to this assumption. The ordering of the other variables corresponds to that used by Clarida and Galí.

We also identify a transitory shock (sixth column) as one whose long-term impact is nil on all of the variables except the cumulative interest rate (sixth row). This could be a demand shock that differs from other demand shocks in that it has no long-term effect on either the real exchange rate or on the price differential. It could also be a shock reflecting the intrinsic volatility (not connected to fundamental factors) of the affected series.

3.2 Expanding the Clarida-Galí model to include a cointegrating vector

The variables we deal with here are the same as those presented in section 3.1. However, we now incorporate the following cointegrating relationship:

$$e_t = \beta + \beta_c c_t + \beta_o o_t. \tag{9}$$

We use the methodology described by King et al. (1991), which consists of combining the prior identification restrictions with the empirical cointegration restrictions to identify reduced-form equations. The procedure is presented in Appendix 3.

Since we have one cointegrating relationship and five non-stationary variables, four permanent shocks must be identified. The permanent components of the model and the reaction functions are identified by imposing a structure on the matrix of long-term multipliers. The specific structure of this matrix is as follows:

$$A = \tilde{A}\Pi = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \beta_c & \beta_o & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \pi_{11} & 0 & 0 & 0 \\ \pi_{21} & \pi_{22} & 0 & 0 \\ \pi_{31} & \pi_{32} & \pi_{33} & 0 \\ \pi_{41} & \pi_{42} & \pi_{43} & \pi_{44} \end{bmatrix} = \begin{bmatrix} \pi_{11} & 0 & 0 & 0 \\ \pi_{21} & \pi_{22} & 0 & 0 \\ \pi_{31} & \pi_{32} & \pi_{33} & 0 \\ \omega_{41} & \omega_{41} & 0 & 0 \\ \pi_{41} & \pi_{42} & \pi_{43} & \pi_{44} \end{bmatrix}.$$

The first, second, third, fourth, and fifth rows of the matrix A represent the long-term impact of shocks on o, c, y, e, and p, respectively. No shock has a long-term effect on the interest rate differential, r, since it is stationary. Various shocks may, however, have a short-term impact on this variable.

The first, second, third, and fourth columns of A represent the long-term impact on the variables of energy-price shocks, non-energy commodity-price shocks, supply shocks, and demand shocks, respectively. As in the case of models that do not incorporate cointegration, but do include commodity prices, we assume that the other shocks have no long-term impact on the price of energy (three zeros in the first row of Π) and that only the price of energy can have a long-term effect on the price of non-energy commodities (two zeros in the second row).

As in Clarida and Galí, supply shocks differ from demand shocks in that only the former result in a long-term change in production (the zero in the third row). In the long run, demand shocks only affect the price differential (three zeros in the fourth column).

We further observe that the estimated cointegrating relationship (as reflected in the matrix A) implies that only shocks to the prices of energy and of non-energy commodities can have a long-term effect on the real exchange rate. Thus, we cannot distinguish real from nominal demand shocks, unlike in the scenario without cointegration, since the cointegrating vector prevents us from identifying demand shocks having a long-term impact on the real exchange rate. What we are left with, therefore, is a combination of these two types of shock.

In addition to shocks having a permanent effect on the variables, we have two transitory shocks whose impact we sum since they are indistinguishable from an economics perspective.[13] As in the case of the transitory shock we saw in section 3.1, we may be dealing with demand shocks with a purely transitory impact on all variables, or with shocks reflecting the intrinsic volatility of the series.

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[13] It is, however, possible to distinguish between them from an econometric perspective, since one has a long-term impact on the cumulative interest rates and the other does not.

4 Results

To facilitate the comparison of our results with those of Clarida and Galí, we begin by updating their estimates. In the second step, we present detailed results for the model with commodity prices and without the cointegrating relationship. We consider this our reference model, since it is more compatible with the tests for cointegration. Next, we present the results of the model including a cointegrating relationship between commodity prices and the real exchange rate. Finally, we provide some robustness tests.

Our principal results are presented with 90 per cent confidence intervals, which we compute using a bootstrap-type resampling method of 1,000 draws. All figures show the percentage change in the series (0.10 = 10 per cent). The horizontal axis represents the number of quarters.

4.1 Update of Clarida and Galí

Clarida and Galí's sample, which also uses quarterly data, is considerably shorter than our own, since it ends in the first quarter of 1992 and begins at the same time as ours. Nevertheless, we obtain results that are virtually identical to theirs. In particular, the reaction functions correspond to the theoretical expectations described in section 2.1. We do not present these reaction functions, but they are available on request.

One important result obtained by Clarida and Galí (and by Dupasquier, Lalonde, and St-Amant 1997), is that variation in the Canada-U.S. exchange rate is explained primarily by real demand shocks. Moreover, the authors find that supply shocks explain a large share of the variance in the GDP differential between the two countries. We obtain the same result from our update of their estimates (also available on request).

The results for supply shocks, real demand shocks, and monetary shocks, presented in section 4.2, are very similar to those generated by the Clarida and Galí model.

4.2 The model with commodity prices and without cointegration

In this section, we incorporate commodity prices into the Clarida and Galí model. What is the expected response of the variables to positive price shocks on commodities? Given that such shocks imply an improvement in Canada's terms of trade (Canada being a net exporter of commodities), they also indicate an improvement in Canadians' relative wealth. Consumption and production are thus both expected to increase relative to the United States (a net importer of commodities). Moreover, the real exchange rate should appreciate since Canada will subsequently be able to attain a desired level of foreign indebtedness by reducing the volume of net exports.[14]

4.2.1 Reaction functions

The figures in Appendix 4 reveal the response of the real GDP differential and of the interest rate differential to the various shocks. Energy and commodity price shocks cause increases in these values by about 8 per cent and 4 per cent, respectively.

As anticipated, shocks to the prices of non-energy commodities and energy have a positive impact on Canada's relative real GDP. However, this effect is weak and not statistically significant. The response of production to the other shocks is very similar to that found by Clarida and Galí. Thus, shocks to supply, real demand, and money drive up relative production in Canada. However, of these three types of shocks, only the supply shock has a long-term impact on the real GDP differential (by construction).

The reaction of the interest rate differential to the various shocks we have identified is weak and not significant. The only exception is the case of the transitory shocks, which drive up the interest rate. These shocks also tend to result in a slight increase in production and prices in the short term. We suspect that these are positive demand shocks to which monetary authorities respond by tightening the money supply to neutralize their impact on the price level.

Here, we are particularly interested in the effect of the various shocks on the real exchange rate, on the nominal exchange rate (which we compute from the response of the price differential and the real exchange rate to various shocks), and on the price differential. As mentioned, these reactions allow us to determine whether the flexibility of the Canada-U.S. exchange rate has facilitated the adjustment of the real exchange rate to shocks. The figures in Appendix 5 illustrate these reaction functions. The reaction functions for the three variables are placed together on one page, while those for price and exchange rate differentials occupy two pages.

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[14] Macklem (1992, 1993) obtains these results in the framework of a dynamic general-equilibrium model of an economy producing three types of goods and with overlapping generations. The long-term implications for production and the exchange rate are ambiguous in this setting, however, because of the movement of factors between the sectors.

Clearly, the reaction functions for the real exchange rate and prices are as expected. Thus, subsequent to a positive supply shock, the real exchange rate depreciates and prices fall in Canada relative to the United States.[15] The opposite result obtains in the case of a shock to real demand and to the price of non-energy commodities. A monetary shock produces a real depreciation in the short term only, but a nominal depreciation in both the short and the long term (though these responses are not statistically significant).

A shock to the price of energy induces a depreciation of the real exchange rate. This result may seem surprising, but it corresponds precisely to the findings of Amano and van Norden and others. However, we observe that this reaction is not statistically significant.

We further observe that, in all cases, adjustment of the nominal exchange rate facilitates the adjustment of the real exchange rate. For example, after a supply shock, the real exchange rate depreciates (as predicted by Clarida and Galí's theoretical model). This real depreciation is almost entirely explained by a nominal depreciation. In the case of a shock to real demand, the real exchange rate appreciates, and again most of this adjustment occurs over the nominal exchange rate. In most cases, the reaction of the real exchange rate cannot be distinguished statistically from that of the nominal exchange rate. Usually, except in the case of a real demand shock and a monetary shock, the reaction of the CPI differential is not statistically different from zero.

These results indicate that, to the extent that prices remain rigid in the short term, adopting a fixed exchange rate will create disequilibrium in markets for labour and production, since under those conditions the real exchange rate's adjustment can only occur over relative prices and not over the nominal exchange rate.

4.2.2 Variance decompositions

Tables 2 and 3 present the contribution of various shocks to the variance of the real exchange rate and production, respectively. Referring to Clarida and Galí's work, we see that adding commodity prices does little to change the results pertaining to the variance of the exchange rate, which remain strongly affected by shocks to real demand. Shocks to commodity prices contribute minimally to explaining this variance in the model omitting the cointegrating vector.

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[15] This result contradicts the predictions of Balassa (1964) and Samuelson (1964).

Table 2
Variance decomposition of the real exchange rate—
Model with cointegration[a]

Horizon	Energy shocks	Commodity shocks	Supply shocks	Real demand shocks	Monetary shocks	Transitory shocks
1 quarter	0 (12)	1 (9)	12 (9)	74 (19)	9 (12)	2 (11)
4 quarters	0 (14)	1 (10)	23 (13)	74 (19)	1 (5)	0 (8)
8 quarters	0 (17)	2 (13)	18 (13)	77 (22)	0 (3)	0 (6)
20 quarters	2 (20)	4 (14)	18 (14)	77 (23)	0 (1)	0 (1)
Long term	2 (21)	3 (14)	18 (14)	77 (24)	0 (1)	0 (2)

a. Simulated standard deviations in parenthesis.

Table 3
Variance decomposition of the real GDP differential—
Model without cointegration[a]

Horizon	Energy shocks	Commodity shocks	Supply shocks	Real demand shocks	Monetary shocks	Transitory shocks
1 quarter	2 (10)	1 (7)	53 (21)	24 (16)	0 (7)	19 (18)
4 quarters	18 (17)	1 (9)	57 (21)	20 (15)	0 (5)	4 (11)
8 quarters	13 (17)	8 (13)	77 (21)	2 (8)	0 (3)	0 (6)
20 quarters	8 (20)	6 (15)	86 (23)	0 (1)	0 (2)	0 (2)
Long term	10 (22)	6 (15)	84 (24)	0 (1)	0 (2)	0 (2)

a. Simulated standard deviations in parenthesis.

As in Clarida and Galí, it is essentially real demand shocks that explain the variance of the real exchange rate. This result would argue in favour of a flexible exchange rate. Indeed, one benefit of a fixed exchange rate is to eliminate the impact of monetary policy shocks as a source of asymmetric shocks. The fact that monetary shocks contribute little to the variance of the real exchange rate suggests that only small gains can be expected in this area.

Conversely, again as in Clarida and Galí, supply shocks explain the bulk of the variation in the real GDP differential in the medium and long term. They are also very significant in the short term, where real demand shocks likewise play a major role. In Clarida and Galí, the domination of supply shocks in the long term is attributable to the identification restrictions. This is not the case here, since nothing keeps the prices of non-energy commodities or of energy from playing a significant role in the determination of this variable in the long term.

4.3 Incorporating a cointegrating vector

We will describe the implications of incorporating a vector of cointegration between commodity prices and the real exchange rate, according to the methodology laid out in section 3.2. Recall that the results of our tests for cointegration led us to attribute less significance to this case.

Most of the reaction functions (available on request) relating the interest rate and the real GDP differential to the various shocks resemble those obtained from the model without cointegration. Reactions to demand shocks here differ from the reactions to real or nominal demand shocks presented in section 4.2. However, there are problems comparing demand shocks between the two models (see section 3.2).

Appendix 6 presents the reactions of the real and nominal exchange rates and of the price differential to the various shocks. The directions of the reaction functions are again similar to those observed in the case without cointegration. Once again, we find that adjustments in the real exchange rate are essentially transmitted over adjustments in the nominal exchange rate. Thus, this result is not sensitive to the presence or absence of the cointegrating vector.

Tables A7.1 and A7.2 (Appendix 7) present the contribution of the various shocks to the variance of the real exchange rate and production, respectively. These results are quite different from those we found in the case without cointegration. In particular, the impact of commodity prices on the variance of the real exchange rate increases considerably in the long term. This is attributable to the fact that we have imposed a cointegrating relationship. The cointegrating vector actually implies that only commodity prices explain the long-term evolution of the real exchange rate. More precisely, the price of non-energy commodities is the key variable for explaining the long-term exchange rate. Nevertheless, it is important to bear in mind that demand shocks and transitory shocks are very persistent. Indeed, after 20 quarters, shocks to the price of non-energy commodities account for only 13 per cent of the variance of the real exchange rate.

The variance decomposition of the GDP differential is also modified by incorporating the cointegrating relationship. The share of GDP's variance explained by supply shocks diminishes, being superseded by shocks to commodity prices in the long term and, in the short and medium term, by transitory shocks.

The great persistence of the impact of transitory shocks may indicate problems with the cointegrating relationship we impose. Indeed, a spurious cointegrating relationship implies a non-stationary, or very persistent, transitory component.

4.4 Sensitivity tests for the results

We performed the following sensitivity tests:

- We verified that the principal results are insensitive to a small increase or decrease in the number of lags.
- We confirmed that reversing the order of the price of energy and the price of non-energy commodities in the models has little impact on the results.
- We verified that the results of the reference model are not sensitive to use of the three-month interest rate differential rather than the overnight rate differential.
- Faust and Leeper (1997) demonstrate the necessity of postulating that the parameter space considered in the context of models with long-term identification restrictions be finite. We assume here that the moving-average representation of the various models is truncated at a finite horizon. We also verify that the results are not sensitive to an increase in the truncation horizon of the moving-average representation of the models.

Conclusions

Our principal conclusions are as follows.

- Exchange rate flexibility facilitates macroeconomic adjustment by accelerating the realignment of the real exchange rate. Relative price movements contribute little to exchange rate adjustment. This result confirms the advantages of a flexible exchange rate, since in a fixed exchange rate regime changes to the real exchange rate would need to occur entirely over price-level changes. In the presence of nominal short-term rigidities, this would create disequilibrium in the markets for labour and for the production of goods and services. This result confirms that obtained by Dupasquier, Lalonde, and St-Amant (1997) using a model without commodity prices. This result is also not sensitive to the addition of a cointegrating relationship into the model.
- Contrary to expectations, our results do not bear out the existence of a cointegrating relationship between the exchange rate and commodity prices. Therefore, we emphasize the results obtained with the omission of this relationship.
- Incorporating commodity prices into our model does little to challenge Clarida and Galí's conclusion that real demand shocks account for the bulk of the variation in the exchange rate over all time horizons. Furthermore, it does not contradict their result that supply shocks are the primary factor in variations in the Canada-U.S. GDP differential for all time

horizons. However, specifying a cointegrating relationship between commodity prices and the real exchange rate implies that, in the very long term, it is the price of non-energy commodities that determines the variation in the real exchange rate.

- The reference model allows us to estimate the relative contribution of monetary shocks to the explanation of the variance of the real exchange rate. This share is minimal (as in Clarida and Galí, among others), providing a further argument in favour of a flexible exchange rate. While a fixed exchange rate eliminates monetary shocks as a source of asymmetric shocks, we estimate this benefit to be negligible.

Clearly, the scope of our results' applicability to the choice of an exchange rate policy for Canada is limited, since we only consider the issue from the perspective of macroeconomic adjustment. To arrive at more general conclusions, one would also need to address the exchange rate regime's impact on factors such as transactions costs, investment, and trade. Political considerations must also play a role.[16]

Several topics for further research are indicated.

- Our results reveal that real demand shocks explain a significant share of the variation in the Canada-U.S. exchange rate. It would be of interest to better understand the precise nature of these shocks. We could, for example, examine the extent to which they reflect fiscal shocks.
- Several of our conclusions depend on whether or not there is a cointegrating relationship between the exchange rate and commodity prices. Our tests reveal that support for the existence of this relationship is not very robust. It would be worthwhile to examine this question in greater detail.

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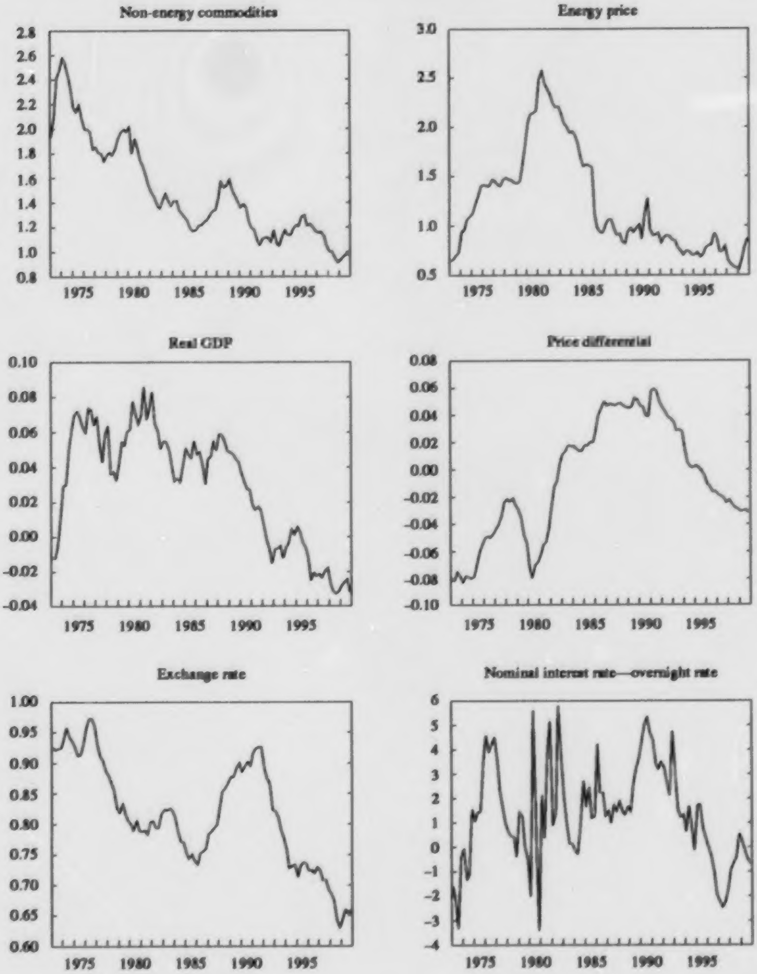
[16] Lafrance and St-Amant (1999) present a survey of the recent literature on optimal currency zones.

Appendix 1
Graphs of the Series

Variables of the model



Non-energy commodities

Energy price

Real GDP

Price differential

Exchange rate

Nominal interest rate—overnight rate

Appendix 2
Augmented Dickey-Fuller (ADF)

Table A2.1
Unit-root tests

	Augmented Dickey-Fuller (ADF)		Phillips-Perron (PP)		Schmidt-Phillips (SP)
Series[a]	**Detrended**	**With trend**	**Detrended**	**With trend**	—
CPI differential	–1,986	–0,877	–1,731	–1,550	–0,122
Real GDP differential	–1,088	–3,819*	–1,334	–3,781*	4,561
Real exchange rate	–1,706	–2,317	–0,716	–2,514	–0,067
Interest rate differential	–2,168	–2,424	–4,699*	–4,854*	47,842*
Energy prices	–1,203	–3,317	–1,543	–3,174	1,494
Non-energy commodity prices	–1,941	–4,294*	–0,871	–4,205*	1,633

a. The number of lags used for the ADF test is chosen using the method suggested by Ng and Perron (1995). The 5 per cent critical value for the ADF and PP tests without trend is –2.89, and that for the tests corresponding with trend is –3.45. Cases in which the unit root is rejected are indicated with an asterisk (*). The critical value for the SP test is 18.1. The unit root is rejected for all first-difference series.

Appendix 3
The King et al. Methodology

After estimating a cointegrated VAR model, or vector-error-correction model, it is possible, as in the case of the structural VAR approach, to represent the stationary economic variables as functions of lagged error terms:

$$x_t = e_t + C_1 e_{t-1} + \ldots = \sum_{i=1}^{\infty} C_i e_{t-1} = C(L)e_t, \tag{A3.1}$$

where e_t is a $(n \times 1)$ reduced-form vector of innovations.

We wish to identify the following structural model:

$$x_t = \Gamma_0 \eta_t + \Gamma_1 \eta_{t-1} + \ldots = \sum_{i=0}^{\infty} \Gamma_i \eta_{t-i} = \Gamma(L)\eta_t, \tag{A3.2}$$

where the structural shocks, η_t, are unknown and Γ_j is an unknown $(n \times n)$ matrix, the typical element of which, τ_{kl}, measures the impact of the l-th structural shock on the k-th variable after i periods.

The first identification constraint stipulates that the matrix $var(\eta_t) = \Sigma_\eta$ be block diagonal, with the two blocks corresponding to the partition $\eta_t = (\eta_t^{p'}, \eta_t^{t'})'$, where η_t^p is the $(k \times 1)$ vector of the model's permanent shocks, and η_t^t is the $[n(n-k) \times 1]$ vector of shocks having a transitory impact on all the variables in the model.

The other identification restrictions are:

$$\Gamma(1) = [\tilde{A}\Pi \; 0], \tag{A3.3}$$

where $\tilde{A}$ is a known $(n \times k)$ matrix of full rank whose columns are orthogonal to the cointegrating vectors, such that $\beta'\tilde{A} = 0$. Π is a $(k \times k)$ lower-triangular matrix with ones in the diagonal, and 0 is an $n \times (n-k)$ matrix of zeros. The matrix Π serves to establish the long-term ordering of the variables. In this, its role is similar to that of the matrix $A(1)$ represented by equations (5) and (6).

Equations (A3.1) and (A3.2) are linked as follows:

$$\Gamma_0 \eta_t = e_t, \tag{A3.4}$$

$$C(L) = \Gamma(L)\Gamma_0^{-1}, \tag{A3.5}$$

$$\text{and } C(1) = \Gamma(1)\Gamma_0^{-1}. \tag{A3.6}$$

Let D be a $(k \times n)$ matrix that solves $C(1) = \tilde{A}D$. Since $C(1)e_t = \Gamma(1)\eta_t = \tilde{A}\Pi\eta_t^p$, we can write:

$$\tilde{A}De_t = \tilde{A}\Pi\eta_t^p \tag{A3.7}$$

$$\text{and } D\Sigma_e D' = \Pi\Sigma_{\eta'}\Pi'. \tag{A3.8}$$

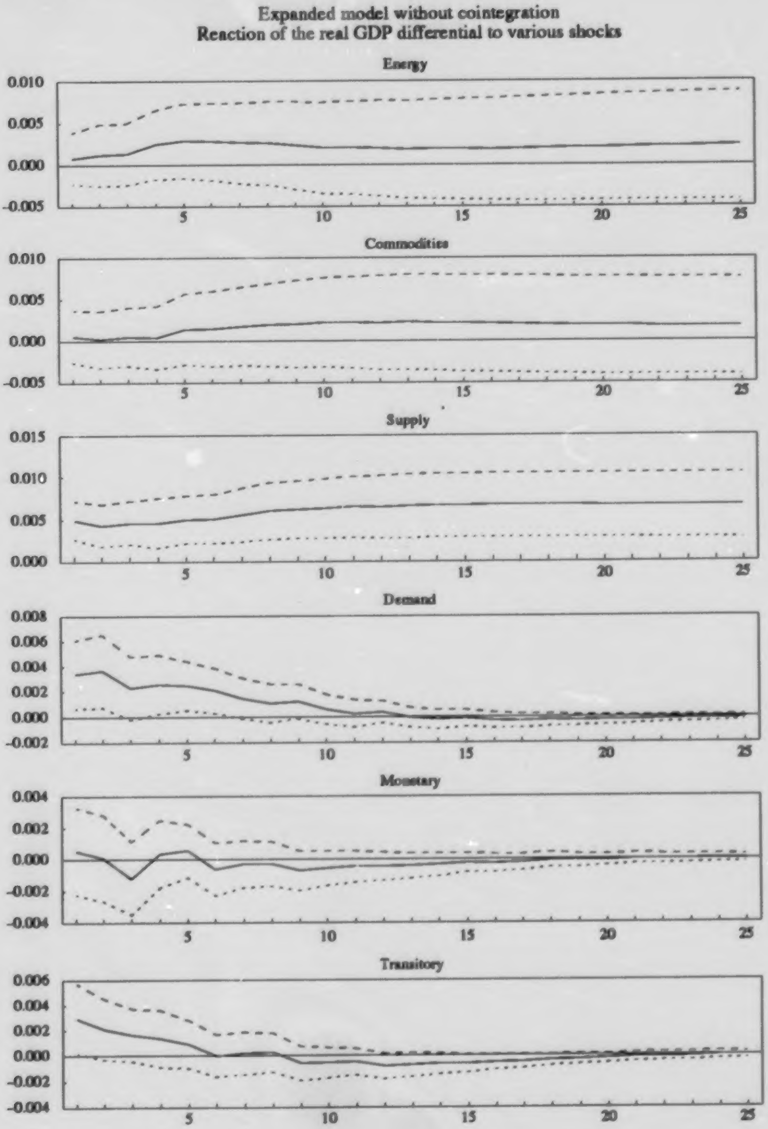
Let $\bar{\Pi} = chol(D\Sigma_e D') = \Pi\Sigma_{\eta'}^{1/2}$. Since Π is triangular, and $\Sigma_{\eta'}$ is diagonal, we obtain a unique solution for Π and $\Sigma_{\eta'}$. From equation (A3.5), we can thus identify the permanent shocks as:

$$\eta_t^p = \Pi^{-1}De_t = Ge_t.$$

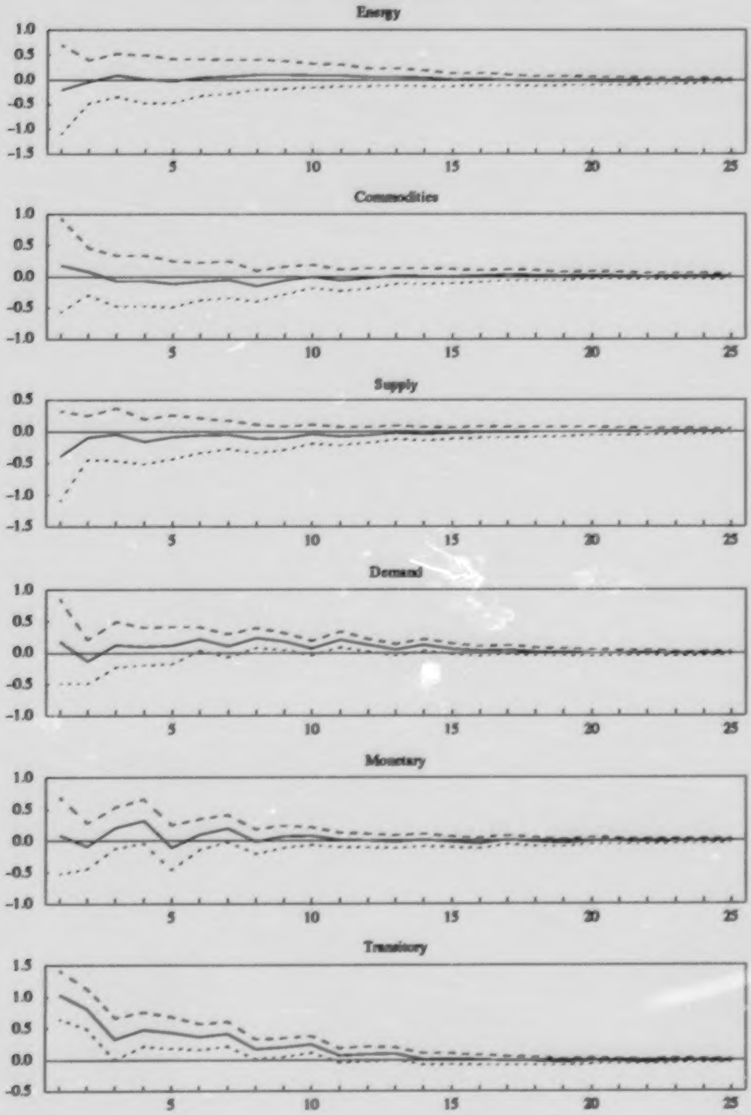
We can easily show (see King et al.) that the matrix Π also allows us to identify the dynamic multipliers for η_t^p using the relationship:

$$\Gamma(L) = C(L)\Sigma_e G'\Sigma_{\eta^p}^{-1}.$$

Appendix 4
Reaction Functions for the Real GDP Differential and the Interest Rate Differential—Expanded Model Without Cointegration

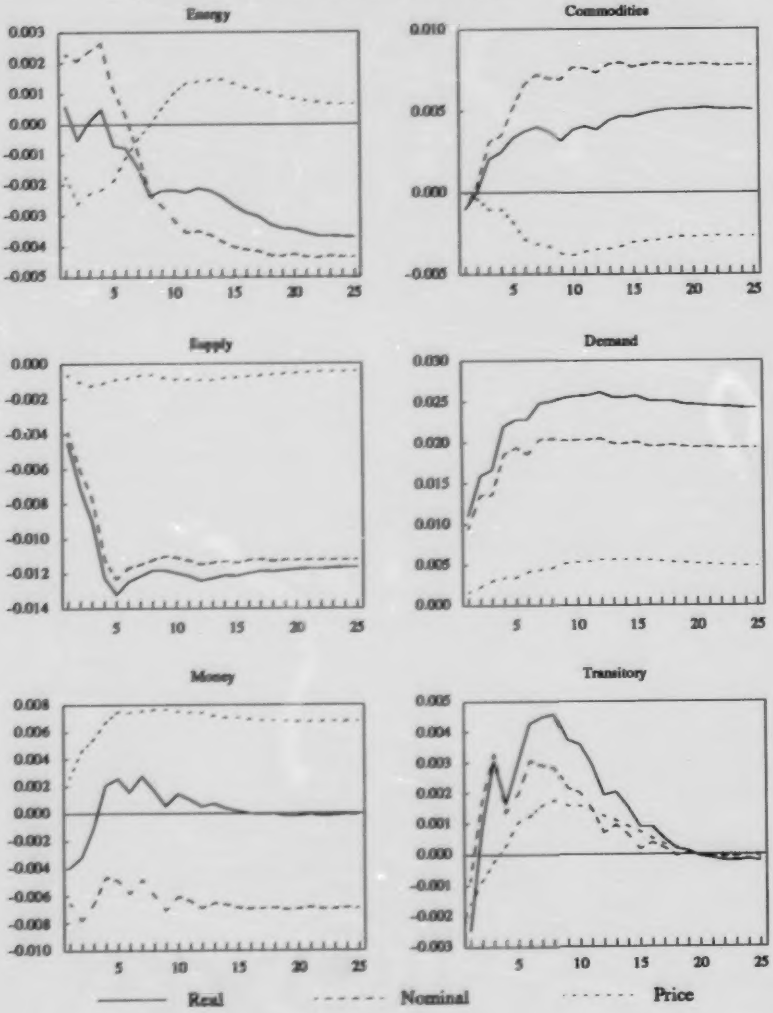

Expanded model without cointegration
Reaction of the real GDP differential to various shocks

Expanded model without cointegration
Reaction of interest rate differential to various shocks

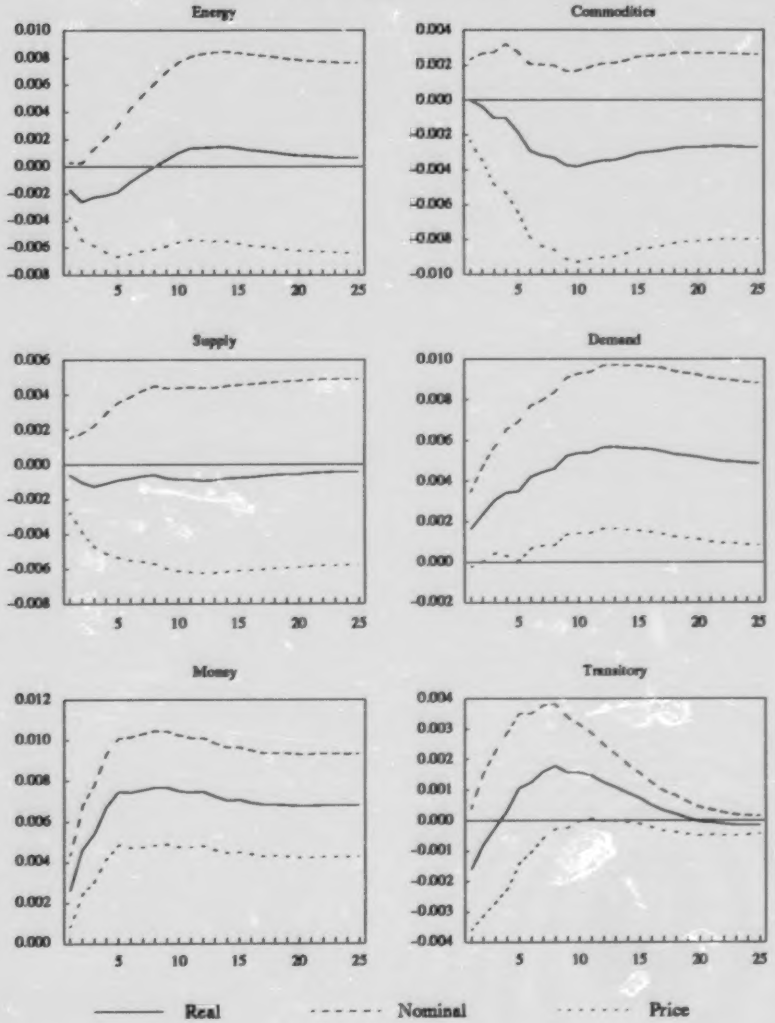


Appendix 5
Reaction Functions for the Exchange Rate and for the Price Differential—Model Without Cointegration

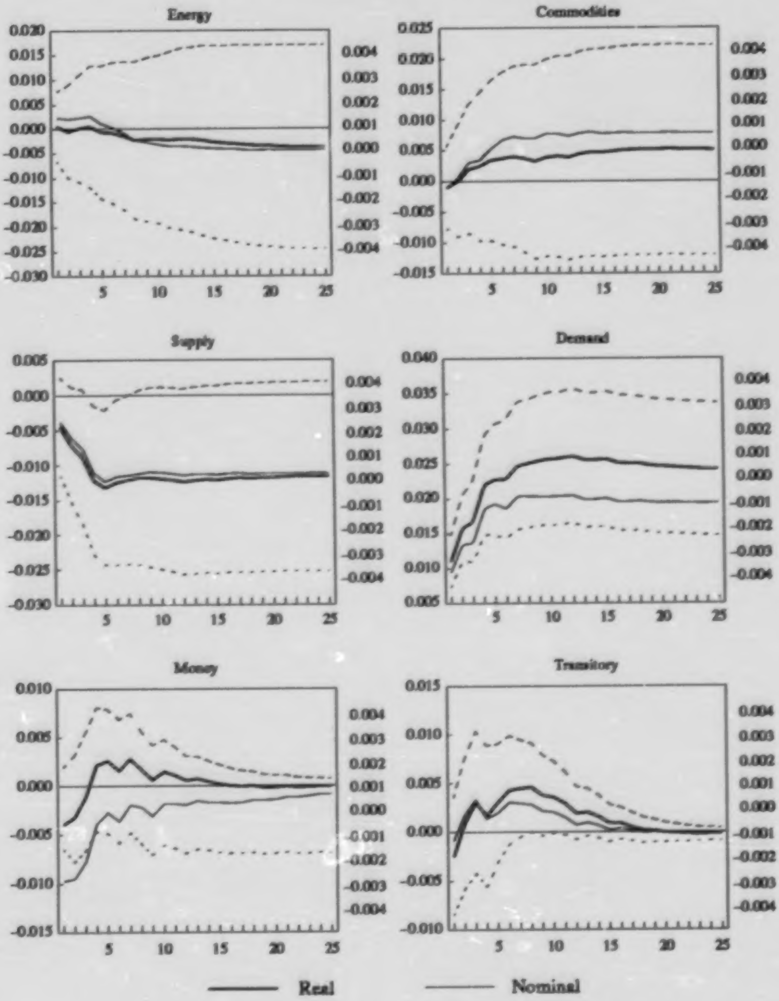
Expanded model without cointegration
Reaction of real and nominal exchange rate and prices to various shocks



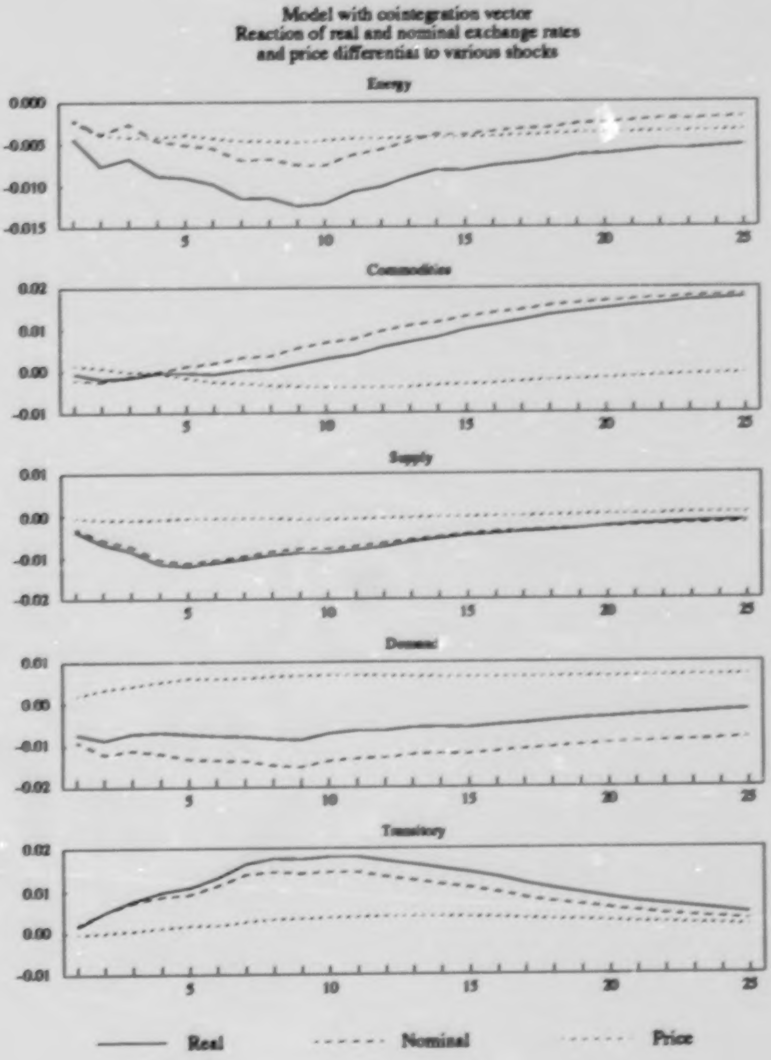
Expanded model without cointegration
Reaction of prices to various shocks with confidence intervals



Expanded model without cointegration
Reaction of real and nominal exchange rate
(with confidence intervals) to various shocks



Appendix 6
Reaction Functions for the Exchange Rate and the Price Differential—Expanded Model with Cointegration



Appendix 7
Variance Decomposition

Table A7.1
Variance decomposition of the real exchange rate—Model with cointegration

Horizon	Energy-price shocks	Commodity price shocks	Supply shocks	Demand shocks	Transitory shocks
1 quarter	14	0	10	38	39
4 quarters	20	1	26	22	33
8 quarters	21	0	24	15	40
20 quarters	19	13	14	10	44
Long term	5	95	0	0	0

Table A7.2
Variance decomposition of real GDP—Model with cointegration

Horizon	Energy-price shocks	Commodity price shocks	Supply shocks	Demand shocks	Transitory shocks
1 quarter	5	0	17	2	77
4 quarters	3	0	17	7	73
8 quarters	6	8	19	6	61
20 quarters	10	35	28	3	24
Long term	14	51	35	0	0

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Discussion

Daniel Racette

A little over a decade ago, the Bank of Canada decided to demonstrate its openness and transparency by holding annual conferences at which academics, colleagues from other central banks, and market actors would be given the opportunity to explore subjects of interest to the researchers and officers of the Bank in their conduct of monetary policy. The topics of these conferences have included the following: understanding the mechanisms of policy transmission, the role of money in those mechanisms, costs associated with fighting inflation, an acceptable definition of price stability, determinants of the exchange rate, and the choice of an exchange rate regime.

Although relatively technical in nature, these subjects are central to the conduct of monetary policy, and the conference participants deal with issues on which reasonable people may have differing opinions. As reading the various submissions reveals, this year's conference was no exception in that respect.

The issue on this year's agenda, addressed squarely by Djoudad, Gauthier, and St-Amant, is not new. I recall having dealt with it myself, along with two co-authors (Racette, Raynauld, and Lalonde 1993), in comments on a text about optimal currency zones (Fenton and Murray 1993) on the occasion of the Bank's second conference in June 1992. In that submission, we reiterated the importance of the Canadian dollar as an adjustment mechanism—examining the issue from the perspective of asymmetrical regional shocks within North America. Using results from a similar model applied to Europe, we also expressed doubts about the merits of the European monetary union, which was at that time taking its first halting steps. I should point out in passing that I had expressed these same concerns at a Banque de France-Université conference in 1989 (Banque de France

1990), where my comments were received with some hostility, since they coincided with the Delors report's hour of glory.

We observe that, far from disappearing, the issue has acquired greater relevance in Canada for at least two reasons. On the one hand, the debate has grown more heated and has increasingly seen respected economists, sometimes representing schools of thought that appear closely related, express diametrically opposed views. On the other hand, this discussion has overflowed into the political arena, occasionally even impinging on the realm of our age-old constitutional debate, making the issue a particularly sensitive one for the people of the central bank.

Fundamentally, I remain a fan of the flexible exchange rate (at least for Canada), no doubt because of my Friedmanian roots. However, I must admit here that my convictions are not as strong as they once were—despite a year spent at the Bank of Canada—owing to the credibility of economists on both sides of the debate, as well as to the fact that the situation may have changed in Canada, leaving the benefits of a dollar that is floating (or should I say sinking like a stone at the time of this conference) less obvious.

In light of what I have just said, it should be clear that this year's conference is of particular interest to me, either to corroborate or refute my opinion. In this context, I need convincing results—more convincing, at least, than those Macklem et al. (2001) presented in a paper earlier in this conference, when they attributed annual welfare gains of about Can$1 billion to the maintenance of a flexible exchange rate regime. Despite the many virtues of the work done by Djoudad, Gauthier, and St-Amant, I remain unsure that their approach is sufficiently convincing, if only because of its partial nature—examining the issue exclusively from the perspective of the exchange rate's impact on macroeconomic adjustment. I am aware, however, that this criticism applies equally to some of my own work.

After this lengthy introduction, let us turn our attention to the concerns this study raises for me.

- First of all, and as is always the case at the Bank of Canada, this study was conducted in an expert fashion—one might say, by the book! Its scientific merit is indisputable.
- This study pushes the use of the VAR model to its limits in relating the differentials of important macroeconomic variables (real GDP, inflation rates, and those interest rates most associated with the process of monetary policy) to the real exchange rate. Furthermore, acting on Jacques Raynauld's (1997) suggestion in his discussion on the Dupasquier, Lalonde, and St-Amant (1997) submission to the 1996 conference, the authors incorporate commodity price shocks. Indeed,

they almost reach the limits of this approach's applicability to such an extent—especially since their results generally confirm those of previous studies—that one might wonder whether we have not reached the point of decreasing returns in the usefulness of such models.

- It should be mentioned that the authors' confirmation of Clarida and Galí's results concerning the negative impact of a positive supply shock on the exchange rate raises concerns as to identification of these shocks. From this perspective, a graphic representation of the behaviour of the shocks would have left room for visual interpretation to the reader.
- The great strength of this paper, of course, is the inclusion of shocks to energy and non-energy commodity prices. The results seem to demonstrate that, in the absence of cointegration, this inclusion does not fundamentally alter previously established results indicating the dominance of real demand shocks in the determination of the real exchange rate. That said, when the authors impose cointegration with commodity prices, the results are very different, with shocks to the price of non-energy commodities dominating. They place very little emphasis on this result, however, deeming that "results supporting cointegration are weak" (pp. 100). Researchers at the Bank of Canada assign considerable importance to the Amano and van Norden model, as witnessed by frequent references made to this model throughout the conference.

  Since this model is characterized by the inclusion of a cointegrating vector, I would have appreciated a greater effort by Djoudad, Gauthier, and St-Amant to reconcile their somewhat contradictory results. Should we conclude that the cointegration result in the Amano and van Norden model is attributable to the exclusion of the other elements of the information set used by the authors, and is thus fortuitous? Either it raises doubts about the pertinence of using Amano and van Norden's equation for modelling the real exchange rate of the Canadian dollar, or should we question Djoudad, Gauthier, and St-Amant's analysis for failing to find a cointegrating vector incorporating such important variables as commodity prices. If Amano and van Norden's model is called into dispute because of Djoudad, Gauthier, and St-Amant's inability to find a cointegrating vector, should we then also doubt the Bank of Canada's recent defence of flexible rates based on benefits to the Canadian economy of exchange rate adjustments in the context of the crisis in Southeast Asia and its impact on commodity prices. I feel the authors might also have considered the results obtained by Smets (1997), who, comparing the case of Canada with that of Australia, found a much smaller role for commodity prices in the determination of the Canadian dollar's exchange rate than do Amano and van Norden.

- Moreover, the results of the study by Djoudad and his co-authors clearly point to price rigidity in Canada, since real shocks do not induce any meaningful reaction in prices. The authors state that "relative price movements contribute little to exchange rate adjustment" (p. 109). On these grounds, we could ask the people at the Bank to measure the implications of this rigidity for the choice of the price-stability goal (the subject of the Bank's recent conference in June 2000), or for the real impact of an inflation rate that is systematically below the mean of the inflation-control band targeted over the course of the past 10 years. Could this be grist for the mill of the supporters of Akerlof, Dickens, and Perry (1996)?
- On another level, the period under examination is that of the flexible exchange rate regime, but can one really speak of a "constant" regime? The various phases of the period between 1970 and the present have been characterized by shocks of qualitatively differing natures and, examining a graph of the real GDP differential between Canada and the United States, we can even doubt the stationarity of this variable in first difference, at least in recent times. Similarly, comparing a graph of the real GDP differential with one of the real exchange rate reveals a striking parallelism. This parallelism may be what keeps the authors from finding a cointegrating relationship with commodity prices. The resulting model is thus dominated by one variable, the exogeneity of which is difficult to justify.

In conclusion, we are witness to an interesting exercise, well carried out and generally supportive of the results of previous studies on the merits of a flexible exchange rate for the Canadian dollar. Nonetheless, given the partial nature of this analysis, it is only after examining the entirety of the studies presented here that we will be able (or not) to strengthen our convictions on this matter. That being said, it is very possible that, whatever results we economists may bring to this debate, ultimately, as in Europe, political considerations will weigh heavily in the final choice of an exchange rate regime for Canada.

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Common-Currency Areas in Practice

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*Andrew K. Rose**

Introduction and Motivation: Can Currency Unions Explain "Home Bias"?

Twelve countries have agreed to surrender monetary sovereignty as they join the European Economic and Monetary Union. Ecuador is currently dollarizing, and a number of other countries have already done so. What are the real benefits of relinquishing monetary control? Should Mexico, Argentina, and even Canada consider abandoning their national currencies and adopting the U.S. dollar?

In this paper, I attempt to address some of these issues. I examine the behaviour of countries that are or have been members of international currency unions. More precisely, I ask whether existing currency unions replicate the desirable features of optimal currency areas as set out by Mundell (1961). Specifically, I ask whether the countries and political units that constitute currency unions are as integrated economically as regions within nations. I find that while a common currency enhances economic integration, the degree of integration is far smaller than within nations.

A number of studies have shown that national borders inhibit economic integration. Internal trade is disproportionately large compared with international trade; relative prices are more stable inside countries than across national boundaries; domestic assets tend to be held disproportionately; and so forth (see Anderson and van Wincoop 2001). The hypothesis I implicitly

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* I wish to thank Graydon Paulin for helpful comments.

investigate is that some part of the "border effect" is the result of exchange rate volatility or, more generally, the consequence of having different national monies.

This paper is empirical—my strategy is to use data on the many existing currency unions. I differentiate between intranational political unions (i.e., sovereign states with a single currency, but also common laws, political environments, cultures, and so forth) and international currency unions (i.e., sovereign countries that have delegated monetary policy to some international or foreign authority but retain sovereignty in other domains). The United States, France, and the United Kingdom are examples of political unions. Behaviour of regions within these countries is the focus of the emerging literature on intranational economics (Hess and van Wincoop 2000; Bacchetta, Rose, and van Wincoop 2001). The CFA[1] franc zone and the East Caribbean Currency Area are examples of currency unions.

My approach is to ask whether currency unions exhibit the type of economic integration that Mundell (1961) argues is desirable for an "optimum currency area." I measure a number of economic characteristics for international monetary unions, intranational political unions, and other countries. Mundell's framework implies that the gains from a common currency are proportional to the size of international transactions. Using disaggregated international trade data, I find that currency unions are more open and more specialized than non-currency-union countries of comparable size. More directly, I examine international trade patterns. Using a gravity equation, I find that trade between members of a currency union (e.g., Brunei and Singapore) is indeed much higher than trade between comparable countries with their own currencies, by a factor of over three. However, even this sizable effect is small in comparison with the "home-market bias," which shows that intranational trade is higher than international trade by a factor of almost 20, even for units of comparable economic size. That is, my estimates show that a hypothetical country as large (in terms of population, GDP, geographic area, and so forth) as Brunei and Singapore combined, would engage in much more intranational trade than Brunei and Singapore do in reality.

I examine real exchange rates and deviations from purchasing-power parity (PPP).[2] The volatility of real exchange rates is lower for members of currency unions than for countries with independent currencies. But some of this effect stems from the fact that no currency union has experienced a hyper-inflation; low-inflation countries with sovereign currencies have real exchange rate volatility that is only slightly higher than that of currency-union members. Currency-union members do not have detectably different rates of mean reversion in their real exchange rates. Compared with the benchmark of exchange rates between cities in comparably sized countries, currency unions exhibit slightly more integrated prices.

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[1] CFA stands for Communauté Financière Africaine or Coopération Financière Africaine.

[2] McKinnon (1963) has argued that, in practice, real exchange rate behaviour does not appreciably depend on the choice of monetary regime, and the desire to influence real exchange rate behaviour does not justify having an independent currency.

I also investigate other characteristics of currency unions. I find that business cycles are systematically more highly correlated between members of currency unions than between countries with sovereign currencies, but not as much as regions of a single country. Finally, I look at risk-sharing between members of currency unions and countries with independent currencies, by examining consumption and income, and I find only a small impact of currency union on risk-sharing.[3]

I conclude that members of a common-currency area are more economically integrated than non-currency-union members, but not nearly as much as those that are fully politically integrated. That is, "dollarized" countries are more likely to satisfy Mundell's criteria for being members of an optimum currency area, but not nearly as much as regions within a single country.

International trade entails foreign exchange transactions, unless it occurs between members of common-currency areas. While one ordinarily thinks of such costs as being small (at least for Organisation for Economic Co-operation and Development (OECD) countries facing deep liquid foreign exchange markets), avoiding these costs seems to have significant consequences. Currency unions may, therefore, encourage integration. Still, I am interested only in the association between integration and currency unions. I do not consider whether causality flows from integration to currency union (integrated countries are more likely to join and remain in currency unions), in the reverse direction (currency union induces integration) or both.[4]

In section 1, I provide a general characterization of currency-union members, taking special note of their openness and specialization. I analyze the impact of currency-union membership on international trade in section 2, and the impact on prices in section 3. Section 4 examines the international synchronization of business cycles, while section 5 looks at risk-sharing. A brief summary and conclusion follow.

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[3] I disregard labour mobility, since it is so difficult to construct an appropriate data set, and because monetary policy can only be used to offset transitory nominal shocks where labour movement is probably inappropriate. I also ignore asset and financial market integration.

[4] It is difficult to examine the direction of causality, since currency unions are long-lived. In Rose (2000), I provide more analysis that supports the idea that currency union tends to promote trade integration rather than the reverse.

1 What Do Common-Currency Areas Look Like?

1.1 A broad-brush description

The first (macroeconomic) data set I use consists of annual observations for 210 "countries" between 1960 and 1996, extracted from the 1998 World Bank World Development Indicators (WDI) CD-ROM (see Appendix 2 for a list of the countries). This data set includes all countries, territories, colonies, and other entities covered by the WDI (all are referred to as "countries," for simplicity), and is comprehensive.[5] (The data set has been checked and corrected.)

In this data set, some 1,891 (country-year) observations (24 per cent of the sample) were for members of a common-currency area; the list of countries can be found in Appendix 1. I include members of common-currency areas (such as Benin, a member of the CFA franc zone); countries that operated without a sovereign currency (such as Panama, which uses the U.S. dollar); long-term 1:1 fixers, where there is substantial currency substitution and essentially no probability of a move from parity (e.g., the Bahamas); and colonies, dependencies, overseas territories/departments/collectivities (such as Guadeloupe). Anchor countries (such as the United States and France), whose currencies are used by others, are tabulated solely for reference (i.e., they are not included as currency-union members in my empirical analysis).[6]

Table 1 shows descriptive statistics for the whole sample of available observations and for (peripheral) currency-union members. The number of available observations is tabulated, along with the mean and standard deviation. There is also a *p*-value for a *t*-test of equality of means for currency-union members and non-members.

Table 1 indicates that members of currency unions tend to be poorer and smaller than non-currency-union members. Currency unions are associated with lower and more stable inflation. However, they have lower ratios of M2 to GDP (a standard measure of financial depth), which may be because they tend to be poor. A better indicator of their financial markets may be the fact that the spread of the domestic loan rate above the London Inter-Bank Offered Rate (LIBOR) tends to be lower (even after one has excluded high-inflation observations). The country-specific standard deviation of the output

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[5] There are, however, many missing observations for variables of interest.

[6] In the case of multilateral currency unions, there is no clear anchor.

Table 1
Descriptive macroeconomic statistics and measures of openness

	Whole sample			Currency unions			Equal? (p-val.)
	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.	
Real GDP per capita ($)	2,454	5,285	5,262	416	3,615	4,474	0.00
Population (millions)	5,102	23.6	9.3	1,052	1.8	2.7	0.00
Inflation (%)	4,152	40.3	499	672	7.8	9.0	0.00
M2/GDP (%)	3,197	38.0	23.9	510	30.4	16.7	0.00
Loan rate—LIBOR (%)	2,131	72.7	2,643	412	5.2	6.9	0.24
Loan rate—LIBOR (%) (inflation<100%)	1,858	7.6	13.3	348	5.4	7.2	0.00
Output growth rate volatility (std. dev. %)	211	6.1	5.5	51	5.9	3.1	0.17
Budget deficit (% GDP)	2,289	−3.6	5.8	268	−3.7	6.1	0.84
Exports (% GDP)	4,732	32.3	23.7	783	39.8	23.5	0.00
Imports (% GDP)	4,729	37.8	25.4	783	53.2	27.1	0.00
Export duties (% exports)	1,621	3.4	6.1	237	2.6	3.8	0.00
Import duties (% imports)	2,226	12.3	9.6	241	18.0	8.4	0.00
Trade taxes (% revenue)	2,252	19.5	17.1	300	31.9	20.1	0.00
Current account (% GDP)	2,942	−4.5	11.5	477	−8.3	13.3	0.00
|Current account| (% GDP)	2,942	7.3	10.0	477	10.8	11.4	0.00
Gross FDI (% GDP)	2,058	1.5	2.6	339	2.0	3.4	0.00
Private capital flows (% GDP)	2,067	12.0	31.6	352	22.4	67.6	0.00

Notes: Obs. = observations.
Std. dev. = standard deviation.

growth rate, a crude measure of output volatility, seems to be similar for currency-union members and non-members. Finally, there is little indication that currency unions are associated with either more or less fiscal discipline.

1.2 Trade patterns of common-currency areas

Currency unions tend to be more open than countries with their own currencies. Exports and imports are larger as percentages of GDP to a degree that is statistically significant and economically important. Interestingly, while export duties are lower, import duties are higher for currency-union members; and the importance of trade taxes is greater. This is probably because most currency-union members have poorly developed income and value-added tax bases. Currency-union members run current accounts that are larger (in absolute value) as a percentage of GDP, and more variable. Currency unions are also more open to private capital flows and to foreign direct investment. That is, both the intertemporal and intratemporal evidence indicate that currency-union members are more open to capital than are non-members.

Members of currency unions appear more open to international flows of goods, services, and capital than countries with their own currencies. But one can overstate the importance of these differences. Currency-union members tend to be small countries, which are known to be more open than larger ones. Accordingly, I control for size and income in determining whether membership in a common-currency area is systematically associated with more intense trade.

Given that members of currency unions are more open to international influences than countries with their own currencies, it is natural to ask whether members of common-currency areas are also more specialized and therefore potentially more vulnerable to asymmetric industry shocks. Kenen (1969) was the first to discuss specialization in this context.

One way of examining this question would be to compare production structures to determine whether currency-union members are more specialized in production. However, no data set exists for this purpose. Nevertheless, it is possible to examine the patterns of specialization exhibited by countries engaging in international trade. To do so, I use the World Trade Data Base (WTDB).

The WTDB is a consistent recompilation of United Nations (UN) trade data, discussed in Feenstra, Lipsey, and Bowen (1997).[7] The WTDB is estimated to cover at least 98 per cent of all trade. Annual observations of nominal trade values (recorded in thousands of American dollars) are available in the WTDB for some 166 countries from 1970 through 1995 (see Appendix 3 for list of countries). These observations are available at the four-digit ("subgroup") Standard International Trade Classification (SITC) level (revision 2). There are a total of 897,939 observations in this three-dimensional panel (goods, countries, and years). A typical observation is the exports (totalling $740,000) from South Africa of SITC good 11 in 1970.[8]

For each country-year observation, I compute the Herfindahl Index, a measure of specialization. The Herfindahl Index is the sum of squared shares of the individual goods, defined as:

$$H_{it} \equiv \sum_{j} (x_{ijt}/X_{it})^2 \qquad j = 1, K, J,$$

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[7] This has been augmented with data from the UN's International Trade Statistics Yearbook.

[8] SITC Code 11 denotes "Animals of the bovine species, incl. buffaloes, live." Other examples of four-digit subgroups include: "Tyres, pneumat. new, of a kind used on buses, lorries" (SITC code 6252), and "Int. combustion piston engines for marine propuls." (SITC code 7133).

where x_{ijt} denotes the exports for country i of SITC subgroup j in year t, X_{it} denotes total exports for i in year t, and the summation is taken over all SITC subgroups. H is bounded by (0,1]; a high value of H indicates that the country is specialized in the production of a few goods.[9]

I have some 3,045 country-year observations of the Herfindahl Index for the WTDB. Of these, 388 (13 per cent) are for countries that are currency-union members. As Table 2 shows, Herfindahl indexes for countries with their own currencies are systematically lower (averaging 0.23) than those for members of currency unions (which average 0.31). That is, members of common-currency areas tend to be more specialized. The difference is not only of economic importance; it is also statistically significant (the t-test for a difference in means is 5.7). Currency-union members also export (122) fewer sub-goods, on average, than countries with their own currencies, consistent with the hypothesis of greater specialization (again, the difference is statistically significant with a t-statistic of 17.7).

Some might point out that since currency-union members are smaller and poorer than other countries, more specialization is to be expected. I control for these other factors by regressing the Herfindahl Index on the Penn World Table (mark 5.6) measure of real GDP per capita, population, and a dummy variable that is unity if the country-year observation is for a currency-union member. The results are tabulated in the bottom part of the table. They show that my conclusions are insensitive to the addition of controls for real GDP per capita and country size. Currency-union members consistently have higher Herfindahl indexes and export smaller numbers of goods.[10] That is, members of currency unions are more open and specialized than countries with their own currencies. Of course, the fact that they are more specialized may make them more vulnerable to industry-specific shocks, and this specialization might be expected to increase the idiosyncratic nature of their business cycles; I will examine that possibility.

2 How Integrated Are Currency Unions in International Trade?

I will show that members of currency unions systematically engage in more international trade. This issue is of obvious interest, since the benefits from using a single money in terms of saved transactions costs depend on the amount of trade between two regions, as recognized since—at least—

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[9] The Canadian Herfindahl Index averaged around 0.04 through the sample, and was bounded by (0.028, 0.055).

[10] My findings are not affected by the inclusion of country- or time-specific fixed effects, or quadratic terms for income, as in Imbs and Wacziarg (2000).

Table 2
Export specialization and currency unions

Descriptive statistics		Herfindahl Index		Number of exports	
	Obs.	Mean	Std. dev.	Mean	Std. dev.
Non-currency-union members	2,657	0.23	0.24	254	132
Currency-union members	388	0.31	0.19	132	89

Regression tests	Regressors		
Regressand	Real GDP per capita	Population	Currency union
Herfindahl Index	–0.10	–2.8	0.06
	(6.8)	(20.2)	(4.4)
Number of exports	0.02	0.0003	–67.2
	(23.9)	(24.3)	(11.9)

Notes: Absolute values of robust t-statistics recorded in parentheses. Intercepts are not reported. Sample size = 2,806 throughout. Coefficients for real GDP per capita (population) multiplied by 10^4 (10^7) for convenience.

Mundell (1961) and subsequently discussed in Alesina and Barro (2000). I follow Rose (2000) in using a "gravity" model of international trade as my framework. In particular, I ask whether bilateral trade between two countries is higher if they both use the same currency, holding constant a variety of other determinants of international trade.

The large literature that uses the gravity model of international trade points to distance, income levels, and country size as the most critical drivers of bilateral trade flows, a result that I corroborate here. The model I use is completely standard and can be written:

$$\ln(X_{ij}) = \gamma CU_{ij} + \beta_0 + \beta_1 \ln(D_{ij}) + \beta_2 \ln(Y_i Y_j / Pop_i Pop_j) + \beta_3 \ln(Y_i Y_j) + \delta * Z_{ij} + \varepsilon_{ij},$$

where X_{ij} denotes the value of bilateral trade between countries i and j, CU is a binary dummy variable that is unity if i and j use the same currency, and zero otherwise. D_{ij} denotes the distance between countries i and j, Y denotes real GDP, Pop denotes population, Z denotes a vector of other controls, the β and δ coefficients are nuisance coefficients, and ε denotes the residual impact of all other factors driving trade. The coefficient of interest to me is γ, which measures the impact of a common currency on international trade. A positive coefficient indicates that two countries using a common currency also tend to trade more.

I begin by estimating this equation using data from the WTDB, augmented by data from the UN *International Trade Statistics Yearbook*. Over 150 countries, dependencies, territories, overseas departments, colonies, and so forth (referred to simply as "countries" below) for which the UN Statistical Office collects international trade data are included in the data set. Country location (used to calculate Great Circle distance) is taken from the CIA's Web site, which also provides observations for other variables of interest, such as contiguity, official language, colonial background, and area.[11] Real GDP and population are taken from the 1998 World Bank World Development Indicators CD-ROM.[12] I use data from 1970, 1975, 1980, 1985, 1990, and 1995 and include time-specific controls.

Estimation results are contained in Table 3. The ordinary least squares (OLS) estimation is used, and robust standard errors are recorded parenthetically. At the extreme left of the table, the simplest gravity model is employed; that is, no auxiliary Z's are included. The β coefficients indicate that the gravity model works well, in two senses. First, the coefficient estimates are sensible and strong. Greater distance between two countries lowers trade, while greater economic "mass" (proxied by real GDP and GDP per capita) increases trade. These intuitive and plausible effects are in line with the estimates of the literature; they are also of enormous statistical significance with t-statistics exceeding 20 (in absolute value). Second, the equation fits the data well, explaining a high proportion of the cross-sectional variation in trade patterns.

While it is reassuring that the gravity model performs well, its role is strictly one of auxiliary conditioning. I am most interested in understanding the relationship between currency-union membership and trade flows after accounting for gravity effects. Even after taking out the effects of output, size, and distance, there is a large effect of a common currency on trade. The point estimates indicate that two countries that share a common currency trade together by a factor of $exp(2.11) \cong 8.25$! This effect is not only

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[11] The 2000 World Factbook is available at: http://www.odci.gov/cia/publications/factbook/index.html.

[12] I sometimes include a control for common membership in a regional free trade agreement. I include a number of such agreements, including the European Union; the Canada-U.S. free trade agreement; the European Free Trade Association (EFTA); the Australia/New Zealand closer economic relationship; the Israeli/U.S. free trade agreement; the Association of Southeast Asian Nations (ASEAN); the Central American Common Market (CACM); the PNG-Australia Trade and Commercial Relations Agreement (PATCRA); the Caribbean Community (CARICOM); the South Pacific Regional Trade and Economic Cooperation Agreement (SPARTECA); and the Cartagena Agreement, all taken from the WTO's web site (http://www.wto.org).

Table 3
Modelling the effect of currency union on trade

Currency union	2.11	1.53	1.22	1.25	1.37
	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
(Log) distance	−1.22	−1.09	−1.09	−1.04	−1.06
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
(Log product) real GDP per capita	0.66	0.64	0.66	0.56	0.49
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
(Log product) real GDP	0.78	0.79	0.80	0.88	0.94
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Regional trade agreement		1.31	1.25	1.08	1.17
		(0.07)	(0.07)	(0.07)	(0.07)
Common language		0.73	0.44	0.57	0.53
		(0.03)	(0.04)	(0.04)	(0.03)
Common land border		0.37	0.43	0.62	0.63
		(0.07)	(0.07)	(0.07)	(0.07)
Common colonizer			0.65	0.47	0.45
			(0.05)	(0.05)	(0.05)
Same nation			1.08	0.97	0.99
			(0.28)	(0.28)	(0.29)
Colonial relationship			2.19	1.99	1.99
			(0.07)	(0.07)	(0.07)
Number of landlocked countries				−0.39	
				(0.03)	
(Log of) sum of land area				−0.22	
				(0.01)	
(Log of) product of land area					−0.15
					(0.01)
Number of island countries					0.04
					(0.02)
R^2	0.61	0.62	0.63	0.64	0.64
Root mean-square error (RMSE)	2.05	2.03	2.00	1.98	1.98

Notes: OLS estimation. Robust standard errors recorded in parentheses.
Year-specific intercepts not recorded.
Sample size = 31,101, 1970 through 1995 at five-year intervals.
Regressand is log of real bilateral trade.

economically large, but also statistically significant at traditional confidence levels (the *t*-statistic exceeds 16).

It is hard to imagine that Canada could increase its trade with the United States eightfold by giving up the loonie. One can think of a number of reasons for this strong result. At the top of the list would be model misspecification, implying that the currency-union variable is picking up the effect of other omitted variable(s). But this is not the case; the results are robust. Four different perturbations of the gravity model are included in Table 3; they augment the basic results with extra (*Z*) controls. These extra effects are usually statistically significant and economically sensible, although they add little to the overall explanatory power of the model. Being partners in a regional trade agreement, sharing a common language, having the same (post-1945) colonizer, being part of the same nation (e.g., France and an overseas department such as French Guiana), and having had a colonizer-colony relationship all increase trade by economically and statistically significant amounts. Landlocked and large countries tend to trade less; islands trade more. But inclusion of these extra controls does not destroy the finding of an economically large and statistically significant positive γ. While the coefficient falls somewhat with extra controls, the lowest estimate of γ in Table 3 indicates that trade is some 340 per cent higher for members of a common currency than for countries with sovereign currencies.

In Rose (2000), I estimated a large number of gravity equations with a comparable data set spanning 1970 through 1990, and found similar results; my point estimate of γ was 1.2. I also showed those results to be robust to: the exact measurement of *CU*, the exact measure of distance, the inclusion of extra controls, sub-sampling, and different estimation techniques.

To summarize: members of a currency union trade more, *ceteris paribus*. A reasonable estimate is that trade is three times as intense for members of a common-currency area as for countries with their own currencies. While this estimate seems provocatively high, it is actually quite low compared with the well-documented size of "home bias" in international trade. McCallum (1995) and Helliwell (1998) find home bias in goods markets to be on the order of 12x to 20x, using data from Canadian provinces and American states. This is far greater than my estimates here (see Anderson and van Wincoop 2001). While membership in a common-currency area does intensify trade, it does not intensify it nearly enough for common-currency areas to resemble countries.

3 Are Prices More Integrated for Currency Unions?

In this section, I explore whether real exchange rates in currency unions are more stable in the sense of converging more quickly and having lower short-run volatility.

To answer the first question, I estimate the equation:

$$qroot_{ij} = \alpha + \beta CU_{ij} + \delta * Z_{ij} + \varepsilon_{ij}.$$

Here, $qroot_{ij}$ is the estimated autoregressive coefficient in an AR(1) regression for the (log of the) real exchange rate of country i relative to country j. A large value of $qroot_{ij}$ indicates slow adjustment of the real exchange rate. CU_{ij} is a dummy variable that takes the value of one if countries i and j were in a currency union for the entire post-1960 period, and a zero otherwise. Z_{ij} is a vector of auxiliary conditioning variables (such as the distance between countries i and j, the volatility of the nominal exchange rate, etc.) that are included in the regression as controls, but that are not directly of interest to us. ε_{ij} is a random error that contains factors that affect the speed of adjustment of real exchange rates that are not included in my regression.

I hypothesize that β_{ij} is negative: that the persistence of real exchange rates is lower for currency-union countries. If currency unions are successful in their objective of reducing real exchange rate volatility, one measure of success is the speed at which real exchange rates converge to equilibrium.

My real exchange rate data are based on annual consumer price indexes and exchange rates from my World Bank macroeconomic data set. For each country in the data set, I first estimate an AR(1) regression (with intercept, given that the price data are in index form) for (log) real exchange rates from 1960 to 1996.[13] I use the slope coefficient in these time-series regressions as the regressand in the cross-sectional regression defined above.[14]

The results reported in Table 4 indicate no support for the hypothesis that real exchange rates adjust more quickly in currency unions. The first column of the table reports results for the basic regression. In addition to the currency-union dummy variable, the regression contains the log of distance (in miles) between countries i and j, a dummy variable for whether i and j are divisions of the same country (e.g., metropolitan France and Guadeloupe), the standard deviation of the first difference of the log of the nominal exchange rate, and a constant. The currency-union dummy variable has a positive sign, but is not statistically significant at conventional levels.

The other variables in the regression are not of direct interest, but I note that two variables are highly significant in this and each of my other specifications: the same-country dummy and the nominal exchange rate volatility. As expected, the coefficient on the same-country dummy is negative, indicating that real exchange rates adjust more quickly for these pairs. Also unsurprisingly, the speed of adjustment is significantly faster when nominal exchange rate volatility is higher. Transitory real exchange rate volatility is closely associated with volatile nominal exchange rates. When shocks to nominal exchange rates are very large and lead to large misalignments of real exchange rates, there is rapid adjustment.

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[13] I only estimate the AR(1) if there are at least 15 observations for each country.

[14] To illustrate with an example, the Canadian-American root is 0.90.

Table 4
Real exchange rate persistence and currency unions

Controls	OLS	Inflation control	Country dummies, inflation	Max. inflation	Without high-inflation countries
Currency union	0.03	0.01	0.10	0.01	–0.00
	(1.0)	(0.5)	(3.9)	(0.3)	(0.1)
(Log) distance	–0.00	0.00	0.02	0.01	–0.00
	(0.5)	(0.0)	(0.5)	(0.2)	(0.4)
Same nation	–0.12	–0.11	–0.06	–0.11	–0.10
	(3.3)	(3.9)	(3.3)	(4.2)	(4.5)
Nominal exchange rate volatility	–0.13	–0.22	–0.16	–0.26	–0.28
	(18.0)	(11.4)	(3.3)	(21.2)	(13.2)
Intercept	0.90	0.89		0.90	0.92
	(34.4)	(34.3)		(34.6)	(34.4)
Number of observations	3,647	3,647	3,647	3,647	3,236

Notes: Absolute values of robust *t*-statistics recorded in parentheses.
Regressand is estimated root from autoregression of log real exchange rate.

The other specifications in Table 4 introduce additional control variables (whose coefficients are not reported in the table). The second column introduces average inflation rates in countries *i* and *j*; their presence does not appreciably alter the effect of the other regressors. The third column includes the same control variables as the second column but also includes a dummy variable for each country. In this specification, the currency-union dummy variable is significant, but with a positive sign. That is, real exchange rates are more persistent in currency-union countries. The fourth and fifth regressions reported in Table 4 control for high inflation in alternative manners. The regression in the fourth column includes the maximum annual inflation rate of each country, while the regression of the fifth column is identical to the base specification reported in the first column but excludes all countries that have experienced high inflation. (High inflation is defined here as average inflation that exceeds 100 per cent.) I find the coefficient on the currency-union dummy is not changed under these specifications. One can conclude from Table 4 that being a member of a currency union does not increase the adjustment speed of real exchange rates. Rose and Engel (2000) provide further corroborative evidence.

To summarize, the speed of adjustment of real exchange rates is not clearly related to monetary union, or even to political union. This result is perhaps not surprising. The literature has found mixed results concerning the speed of adjustment of prices within countries and across borders. Parsley and Wei (1996) find that prices converge rapidly between cities in the United States. The speed of convergence is much greater than is typically found for real exchange rates between countries (see Rogoff 1996). But, their data are for prices of very narrowly defined goods (as opposed to the aggregate price indexes used in international comparisons), and they have no comparable data for countries other than the United States. In contrast, Rogers and Jenkins (1995) and Engel, Hendrickson, and Rogers (1997) find no significant difference between intranational and international speeds of convergence of aggregate real exchange rates.

In contrast, there is a well-known "border" effect for short-term volatility of real exchange rates. For example, Engel and Rogers (1996) find that U.S.-Canadian relative prices are far more volatile than relative prices between cities within each country, even taking into account distance between cities. I ask here whether currency unions have a similar effect in reducing real exchange rate volatility. In Table 5, I report results from regressions of the form:

$$qvol_{ij} = \alpha + \beta CU_{ij} + \delta * Z_{ij} + \varepsilon_{ij}.$$

Here, $qvol_{ij}$ is a measure of the volatility of the real exchange rate of countries i and j. I use as my measure the standard deviation of the residual from the AR(1) regressions discussed above. This measures the volatility of shocks to real exchange rates, as distinct from variance arising from slow adjustment. As before, CU_{ij} is a dummy variable that takes the value of one if countries i and j were in a currency union. Z_{ij} is a vector of other variables that are included in the regression as controls, and ε_{ij} is a random error.[15]

The regression specifications across the five columns of Table 5 are identical to those of Table 4, except that the regressand is the *volatility* of the real exchange rate rather than its *persistence*. In all specifications, the currency-union dummy variable is negative and is highly significant in all but the last specification. The specification that appears most plausible here is the third one, which contains dummy variables for each country. In this regression, the log of distance has a positive and significant sign, indicating that more distant countries have greater real exchange rate volatility. The variance of the change in the (log) nominal exchange rate is a highly significant variable in this regression (and all others). My interest is focused on the currency-union dummy, which is very statistically significant: being a member of a currency union reduces the standard deviation of annual real exchange rates by 6 percentage points.

I conclude that real exchange rates have much lower short-term volatility among currency-union countries, even holding constant the volatility of the

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[15] To continue with the example, the Canadian-U.S. volatility is 3.8 per cent.

Table 5
Real exchange rate volatility and currency unions

Controls	OLS	Inflation control	Country dummies, inflation	Max inflation	Without high-inflation countries
Currency union	–0.04	–0.02	–0.06	–0.02	–0.01
	(5.9)	(3.4)	(7.9)	(3.3)	(0.8)
(Log) distance	–0.005	–0.005	0.005	–0.006	–0.000
	(2.2)	(2.8)	(6.1)	(3.5)	(0.1)
Same nation	0.05	0.04	0.00	0.04	0.02
	(1.5)	(1.7)	(0.4)	(1.8)	(1.5)
Exchange rate volatility	0.28	0.40	0.11	0.41	0.48
	(27.5)	(24.4)	(4.5)	(31.2)	(39.6)
Intercept	0.12	0.11		0.11	0.05
	(7.2)	(6.9)		(7.8)	(5.0)
Number of observations	3,647	3,647	3,647	3,647	3,236

Absolute values of robust *t*-statistics recorded in parentheses.

nominal exchange rate. That is, the reduction in real exchange rate variance is not solely attributable to fixed exchange rates; currency-union membership appears to stabilize real exchange rates through other channels as well. But, real exchange rate volatility of currency-union members is still higher, on average, than for cities within countries.

4 Business Cycle Synchronization and Currency Unions

I now examine whether countries that use the same currency tend to have more highly synchronized business cycles. This has been a natural question to ask since Mundell (1961); countries with highly synchronized business cycles forego little monetary independence if they share a common currency. Thus, countries with highly synchronized business cycles have a higher propensity to adopt a common currency (Alesina and Barro 2000). Of course, since a common monetary policy also eliminates idiosyncratic monetary policy, causality flows in the reverse direction. Members of a common-currency union should experience more synchronized business cycles, since they do not experience national monetary policy shocks. Rather than try to determine either part of the relationship structurally, I am simply interested here in discovering whether members of a common-currency area experience more synchronized business cycles. This question is particularly interesting, because I have already found that currency-union members are quite specialized in international trade, making them potentially subject to asymmetric shocks.

The regressions I estimate take the form:

$$Corr(s)_{ij} = \alpha + \beta CU_{ij} + \delta * Z_{ij} + \varepsilon_{ij},$$

where $Corr(s)_{ij}$ denotes the estimated correlation between real GDP for country i and real GDP for country j detrended with method s; CU is a binary dummy variable that is unity if countries i and j are members of the same currency union; α and δ are nuisance coefficients, Z is a vector of controls, and ε denotes omitted residual factors. The coefficient of interest is β; a positive β indicates that two countries with a common currency tend to have more tightly correlated business cycles. Since my analysis is reduced-form in nature, I am not able to determine whether countries with more tightly synchronized business cycles tend to belong to common-currency areas, or whether membership in a currency union tends to synchronize business cycles (or both).

In forming the regressand, I take advantage of my macroeconomic data set (the list of potential countries is tabulated in Appendix 1). For each pair of countries in the sample, I estimate the bivariate correlation between detrended annual real GDP for countries i and j over the sample period from 1960 to 1996 (or the maximum available span of data).[16] I use country-specific first-differences of natural logarithms to detrend the data; log-linear time-trend models produce similar results. After (the natural logarithm of) each country's real GDP has been detrended, I estimate simple bivariate correlations between the detrended GDP series.[17] Results are tabulated in Table 6.[18]

The extreme left column of each of the tables presents a simple OLS regression of business cycle synchronization on the currency-union dummy variable. I find a positive β coefficient, indicating that business cycles are more synchronized for countries that trade more. The size and statistical significance of the estimate depend on the detrending method used.

Six perturbations of the basic model are also displayed in Table 6 to check the sensitivity of the analysis. The first five perturbations (all estimated with

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[16] I only estimate the bilateral correlation if I have at least five matching GDP observations for each country.

[17] Thus, I first separately detrend Afghani and Australian real GDP by taking growth rates. I then estimate the correlation between the two detrended real GDPs over time (the actual correlation is -0.002). I repeat this procedure for all possible country pairs, and this results in a vector of correlations. For regressors, I use the same set of regressors used in the gravity model of trade. That is, I model business cycle synchronization as being a function of the distance between the countries, the product of their real GDPs, the product of their real GDP per capitas, and so forth.

[18] The Canadian-U.S. correlation is 0.81.

Table 6
Business cycle synchronization and currency unions

Currency union	0.05	0.10	0.07	0.11	0.11	0.10	0.11
	(1.4)	(1.9)	(1.3)	(2.0)	(2.0)	(1.9)	(2.1)
(Log) distance		–0.04	–0.03	–0.03	–0.03	–0.02	
		(8.8)	(4.7)	(4.7)	(4.7)	(4.3)	
(Log product) real GDP per capita		0.04	0.04	0.03	0.04	0.04	
		(15.0)	(13.6)	(13.1)	(11.8)	(12.8)	
(Log product) real GDP		0.00	0.00	0.00	0.00	–0.00	
		(2.7)	(2.7)	(1.7)	(1.3)	(0.7)	
Regional trade agreement			0.14	0.15	0.15	0.16	
			(6.5)	(7.0)	(6.2)	(7.4)	
Common language			0.02	0.03	0.03	0.03	
			(1.8)	(3.2)	(3.2)	(3.2)	
Land border			0.05	0.04	0.04	0.04	
			(1.6)	(1.4)	(1.4)	(1.2)	
Common colonizer				–0.08	–0.08	–0.07	
				(5.7)	(5.5)	(4.7)	
Same nation				0.13	0.13	0.14	
				(1.3)	(1.3)	(1.4)	
Colonial relationship				–0.05	–0.05	–0.04	
				(1.8)	(1.8)	(1.3)	
Number of landlocked countries					0.00		
					(0.0)		
(Log of) sum of land area					0.00		
					(0.1)		
(Log of) product of land area						0.00	
						(1.8)	
Number of island countries						–0.02	
						(3.5)	
(Log of) bilateral trade							0.02
							(13.4)
RMSE	0.262	0.236	0.234	0.233	0.233	0.233	0.243

Notes: Regressand is bilateral correlation of real GDPs (1960–96), detrended by first-difference of natural logs.
OLS estimation, except for last column (instrumental variables with first nine regressors as instrumental variables).
Absolute robust *t*-statistics recorded in parentheses. Intercepts not recorded.
Sample size = 4,419, except for bivariate regression where sample size = 5,913.
Regressand is bivariate correlation of real GDPs (1960–96), detrended via growth rates.

OLS) simply add extra control regressors to the right-hand side of the equation (i.e., extra Z's). I chose the five different sets of regressors used in Table 3 (they encompass the controls used by Clark and van Wincoop (1999); other controls sets, including country fixed effects, deliver similar results). Robust t-statistics are displayed in parentheses.

The estimates in Table 6 indicate that business cycles are more tightly synchronized for members of a currency union. The exact point estimate depends on both the detrending method and the exact set of auxiliary regressors. But the coefficient is consistently positive and almost always statistically significant at conventional levels. Being a member of a common-currency area increases international business cycle correlations by perhaps 0.1, an economically significant amount.[19]

In the right-hand column of the tables, the natural log of bilateral trade between countries i and j is used as the sole control regressor, following Frankel and Rose (1998). This is an important test of the model, since Clark and van Wincoop find that inclusion of trade as a control destroys the border effect. When trade is included, its coefficient is estimated with IV, using the first nine regressors of the gravity equation as instrumental variables.[20] Trade appears to have a strong positive effect on business cycle synchronization. This result corresponds well with the literature. For instance, Frankel and Rose found that increased international trade induces more tightly synchronized business cycles, using data from the OECD; my result is consistent with theirs. Controlling for trade, however, does not destroy the significance of β.

To summarize, countries that are members of a common-currency union tend to have more highly synchronized business cycles; the correlation is perhaps 0.1 higher on average for currency-union members than for non-members. While economically and statistically significant, the size of this effect is small in an absolute sense. Most recently, Clark and van Wincoop compare the coherences of business cycles within countries and across countries, using annual data for both employment and real GDP. They show that intranational business cycle correlations are approximately 0.7 for regions within countries, but in the range of (0.2, 0.4) for comparable regions drawn across countries. That is, the effect of international borders on business cycle synchronization ranges between 0.3 and 0.5. Thus, only a small part of the "border effect" is explained by membership in a common-currency area.

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[19] As a robustness check, I have substituted the correlation between labour forces for the correlation between GDPs (employment, unemployment, and industrial production data are simply not available for many countries, even at the annual frequency). This regressand also delivers a consistently positive, statistically significant effect of currency union on business cycle coherence.

[20] This is necessary, because while trade may affect business cycle synchronization, it is equally plausible that causality flows in the reverse direction, as pointed out by Frankel and Rose.

5 Common-Currency Areas and Risk-Sharing

In this section, I turn to international risk-sharing. It is well known that the apparent degree of international risk-sharing is low. In a classic contribution, Feldstein and Horioka (1980) found that national saving and investment rates are highly correlated, apparently inconsistent with international risk-sharing. Alternatively, if risk-sharing opportunities were widespread, there should be little country-specific idiosyncratic consumption risk. As Backus, Kehoe, and Kydland (1992) noted, in the presence of risk-sharing, consumption should be more highly correlated than output across countries. In fact, the data show the opposite. Furthermore, as French and Poterba (1991) and others have reported, there is strong home bias in asset holdings. There seems to be very little international diversification of portfolios.

Obstfeld and Rogoff (2001) have argued that international risk-sharing might be diminished in the presence of transactions costs. Specifically, they cite costs of trading goods (rather than assets) as an impediment. They also note that these costs might conceivably be related to the need to make foreign exchange transactions to buy and sell goods internationally. In other words, countries that are members of currency unions might do more risk-sharing.

I run a cross-sectional regression of the form:

$$ccorr_{ij} = \alpha + \beta CU_{ij} + \delta * Z_{ij} + \varepsilon_{ij},$$

where, $ccorr_{ij}$ is calculated as the correlation of the first difference in the log of consumption per capita for country i with the analogue for country j. The right-hand side of the regression is of the same generic form as the regressions of the previous two sections. Thus, CU_{ij} is a dummy variable that is unity if countries i and j were in a currency union; Z_{ij} is a vector of control variables; and ε_{ij} is a random error. The consumption data in this section are taken from the Penn World Tables, and are adjusted for PPP. The data are annual, and the maximum data span available is from 1960 to 1992.[21]

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[21] Again, I only estimate the bilateral correlation if I have at least 15 matching observations for each country. The Canadian-U.S. consumption correlation is 0.67.

Table 7 reports the regression results. If risk-sharing is greater among currency unions, I expect a positive coefficient on the currency-union dummy. If more distant countries find it more difficult to share risks, I also expect a negative coefficient on the log of distance. I report results from six regressions. All of them include the currency-union dummy and log distance as explanatory variables. The first regression (reported in the first column) uses a single intercept. The second regression uses a comprehensive set of country-specific fixed effects, so that the dummies for both *i* and *j* take on a value of one when the regressand is $ccorr_{ij}$. The third regression is identical to the first, but is estimated with weighted least squares.[22] The second set of three regressions repeats the analysis, but augments the regression with the bivariate correlation between the growth rates of output (that is, the correlation of the first difference in the log of output for country *i* with the analogue for country *j*, the analogue to the regressand).

The results are weak. The log of distance always enters significantly with the correct sign. The currency-union dummy always enters with the correct sign. However, it is not significant in the first specification; it is only of marginal significance in the second; and it is highly significant only in the third. In all three estimates, the economic size of the effect of currency unions is small. For instance, the currency-union effect is to increase the consumption correlation by 0.04 with weighted least squares. Since the intercept term in the regression is 0.31, then ignoring the effect of distance (that is, for two countries whose log distance is zero), being in a currency union raises the consumption correlation from 0.31 to 0.35.

Even these modest results may overstate the risk-sharing opportunities within currency unions. A high correlation of consumption for a pair of countries may not actually reflect greater risk-sharing opportunities between those two countries. It may simply reflect less idiosyncratic risk. That is, the consumption of two countries may be correlated simply because their output is correlated. Thus, even in the absence of avenues for risk-sharing, there may be a high consumption correlation that should not be interpreted as indicating substantial international risk-sharing.

This concern is particularly relevant, since in the previous section I found that business cycles are more highly correlated for currency-union countries. Therefore, controlling for the degree of output correlation is a potentially important robustness check. I pursue this by adding the actual correlation of (detrended) GDP per capita as a control in the right-hand columns of

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[22] Specifically, I give proportionately greater weight to observations in which the correlation is based on more data. That is, when I can base a correlation on 32 years of data, that correlation in the cross-sectional regression receives double the weight of a correlation based on only 16 years of data.

Table 7
Risk-sharing and currency unions: Consumption correlations

Controls	OLS	Country dummies	Weighted least squares	OLS	Country dummies	Weighted least squares
Currency union	0.05	0.10	0.04	0.07	0.11	0.03
	(0.9)	(1.8)	(4.13)	(1.2)	(1.9)	(3.9)
Log of distance	–0.03	–0.04	–0.03	–0.02	–0.03	–0.02
	(6.3)	(7.9)	(39.9)	(3.4)	(5.9)	(22.9)
Constant	0.29		0.31	0.15		0.39
	(7.8)		(49.1)	(4.3)		(166.2)
Output correlation				0.28	0.19	0.16
				(19.4)	(12.3)	(26.3)

Note: Absolute value of robust *t*-statistics reported in parentheses.

Table 7. As it turns out, the output correlation coefficient is always statistically and economically significant as a control variable, but its presence has little effect on my estimate of β.

I have found little statistically and economically significant evidence that international risk-sharing is enhanced by membership in a currency union. This is perhaps unsurprising, given the absence of substantive international fiscal-transfer arrangements and the shallow private financial markets of most currency-union members.

Summary and Conclusion

This paper contributes to the dollarization dialogue by quantifying some of the features associated with common currencies, using actual data. Using the historical record, I have found that the extra degree of integration associated with a common currency is substantial but finite. Members of international currency unions tend to experience more trade, less volatile exchange rates, and more synchronized business cycles than do countries with their own currencies.

Of course, since well-integrated countries are more likely to adopt a common currency, some of these integration "effects" of currency union may be illusory. In other words, the causality may flow from integration to currency union rather than the reverse.

While members of international currency unions are more integrated than countries with their own monies, they remain far from integrated when compared with the intranational benchmark of regions within a country.

Appendix 1
Currency Unions in the Macroeconomic Data Set

CFA franc zone

Benin
Burkina Faso*
Cameroon
Central African Republic
Chad
Comoros
Congo (Republic of)
Côte d'Ivoire
Equatorial Guinea
Gabon
Guinea-Bissau
Mali
Niger
Senegal
Togo

United States

American Samoa
The Bahamas
Bermuda
Guam
Liberia
Marshall Islands
Micronesia (Federated States of)
Northern Mariana Islands
Palau
Panama
Puerto Rico
Virgin Islands (U.S.)

France

French Guiana
Guadeloupe
Martinique
Mayotte
Monaco
New Caledonia
Reunion

East Caribbean Currency Area (ECCA)

Antigua and Barbuda
Dominica
Grenada
St. Kitts and Nevis
St. Lucia*
St. Vincent and the Grenadines

South Africa

Lesotho
Namibia
Swaziland

United Kingdom

Channel Islands
Ireland
Isle of Man

Australia

Kiribati
Tonga

East Africa

Kenya*
Tanzania
Uganda

France* and Spain

Andorra

India

Bhutan

Singapore

Brunei

Denmark

Faeroe Islands
Greenland

Switzerland

Liechtenstein

Belgium

Luxembourg

Israel

West Bank and Gaza

* Denotes country treated as anchor in multilateral currency unions.

Appendix 2
Countries, Territories, Colonies, and Other Entities in the Macroeconomic Data Set

Afghanistan, Albania, Algeria, American Samoa, Andorra, Angola, Antigua and Barbuda, Argentina, Armenia, Aruba, Australia, Austria, Azerbaijan, The Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bermuda, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Cayman Islands, Central African Republic, Chad, Channel Islands, Chile, China, Colombia, Comoros, Congo (Democratic Republic of), Congo (Republic of), Costa Rica, Côte d'Ivoire, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt (Arab Republic of), El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Faeroe Islands, Fiji, Finland, France, French Guiana, French Polynesia, Gabon, The Gambia, Georgia, Germany, Ghana, Greece, Greenland, Grenada, Guadeloupe, Guam, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong China, Hungary, Iceland, India, Indonesia, Iran (Islamic Republic of), Iraq, Ireland, Isle of Man, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Korea (Democratic People's Republic of), Korea (Republic of), Kuwait, Kyrgyz Republic, Lao PDR, Latvia, Lebanon, Lesotho, Liberia, Libya, Liechtenstein, Lithuania, Luxembourg, Macao, Macedonia FYR, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Martinique, Mauritania, Mauritius, Mayotte, Mexico, Micronesia (Federated States of), Moldova, Monaco, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, Netherlands Antilles, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Northern Mariana Islands, Norway, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Puerto Rico, Qatar, Reunion, Romania, Russian Federation, Rwanda, Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia and Montenegro (formerly Yugoslavia), Seychelles, Sierra Leone, Singapore, Slovak Republic, Slovenia, Solomon Islands, Somalia, South Africa, Spain, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Vanuatu, Venezuela, Vietnam, Virgin Islands (U.S.), West Bank and Gaza, Yemen (Republic of), Zambia, and Zimbabwe.

Source: World Bank World Development Indicators, 1998.

Appendix 3
List of Countries

Afghanistan, Albania, Algeria, Angola, Argentina, Australia, Austria, Bahamas, Bahrain, Bangladesh, Barbados, Belize, Benin, Bermuda, Bhutan, Bolivia, Brazil, Brunei, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cayman Islands, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo (Republic of), Costa Rica, Côte d'Ivoire, Cuba, Cyprus, Denmark, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Ethiopia, Faeroe Islands, Fiji, Finland, France, French Guiana, Gabon, Gambia, Germany (West), Ghana, Greece, Greenland, Grenada, Guadeloupe, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Kiribati, Korea (Democratic People's Republic of), Korea (Republic of), Kuwait, Lao, Lebanon, Liberia, Libya, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Martinique, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar (Burma), Nepal, Netherlands, Netherlands Antilles, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Reunion, Romania, Rwanda, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Solomon Islands, Somalia, South Africa, Spain, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sudan, Suriname, Sweden, Switzerland, Syria, Taiwan, Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Uganda, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Vietnam, Western Samoa, Yemen North, Yugoslavia, Zaire, Zambia, and Zimbabwe.

Source: World Trade Data Base.

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Discussion

Graydon Paulin

Overview

The paper by Andrew Rose examines the impact of currency unions on the economic behaviour and performance of their members. This empirical paper uses results from a gravity model of international trade as its key component. To obtain a sufficiently large sample of countries participating in currency unions, the author uses data sets that incorporate a broad range of economic areas. Areas such as Micronesia, Kiribati, the Channel Islands, Monaco, and Greenland, all members of a currency union, are not the standard fare of macroeconomic analysis. My own view, however, is that there is a wealth of information in these data sets that is all too often ignored. The author's efforts to put them to good use are therefore to be welcomed. Of course, we must be concerned with how well the results obtained for relatively small economic units will apply to much larger ones, such as Canada, Europe, and the other large industrialized economies. The results may not scale in a linear fashion. I'll return to this point.

Currency Unions and Trade

Perhaps the most interesting, and provocative, result relates to the impact of a currency union on trade among participating members. The base result suggests that trade between two members of a currency union will be over eight times greater than would have otherwise been the case. Turning it around, this suggests that there are large impediments to trade created by the lack of a common currency. Assuming that increased trade is welfare-enhancing, then this points to significant potential benefits from joining such a union.

A determined effort is made to check the robustness of this result, including the addition of a number of conditioning variables, such as the presence of regional trade agreements and variables drawing on cultural similarities (e.g., a common language). While the magnitude of the trade effect declines, to about 3 1/2 in one equation, the impact is still large and statistically very significant.

The question we must ask, however, is why is this happening—why does a currency union boost trade to such an extent (even more than a regional trade agreement, according to the author's results)? The traditional response has been that between countries with separate currencies, exchange rate volatility creates uncertainty that could lower the equilibrium level of trade. However, the literature typically does not demonstrate a large impact through this channel. A survey by Bank of Canada economist Agathe Côté, for example, finds very little impact from exchange rate volatility onto trade (Côté 1994). In fact, earlier work by Rose (1999) included a measure of nominal exchange rate volatility as an additional conditioning variable. A negative impact from exchange rate volatility to trade was obtained (although one must be careful of possible simultaneity bias), but a large and *separate* positive impact from the presence of a currency union remained.[1]

So what exactly is at work here? Perhaps a currency union does lend itself to something similar to a "home-bias" effect that has been shown with respect to intraregional trade. Although this effect remains robust in response to the addition of various conditioning variables, the apparent size of the "home-bias" effect is still surprisingly large in an absolute sense. This raises the possibility that the currency-union variable is picking up some other aspect of the trade relationship between these countries.

Causality is one potential problem. The author is clear that his paper does not directly address the issue of causality between currency union and trade, given the reduced-form approach. But if countries that have an above-average propensity to trade with each other are more likely to enter into currency unions, it may not be appropriate to interpret the results as meaning that currency unions lead to higher trade.

A second problem is the accuracy and interpretation of the trade data. Putting aside the inevitable problem of incomplete or inaccurate data, trade in the small economic units under investigation is subject to a number of possible biases. This is important when you consider that many countries in the currency-union sample have a relatively high degree of trade openness. In part, this is a reflection of their small size, leading to a dependence on trade to secure access to a broad range of goods. But exports alone, for a good number of the countries in the sample, exceed 50 per cent of GDP.

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[1] In one example, Rose shows that entering a currency union could have a positive impact on trade an order of magnitude greater than reducing exchange rate volatility to zero.

Some currency-union countries undertake substantial transshipment of goods, which can boost their trade figures enormously. Re-exports occur as part of all countries' trade, but they can account for a relatively large proportion of trade in small economies. The principal database used in the analysis (the World Trade Data Base) in fact makes some adjustment for entrepôt trade, but the adjustment is partial at best. As a result, exports of domestic goods may be overstated for this group of small countries.

Some of these island economies (that are part of currency unions) have had large petroleum refineries located in them, which can have a huge impact on domestic GDP and exports. Other economies receive substantial financial assistance from anchor countries (or other sources). Some of them belong to custom unions with the anchor country or other currency-union members. On this latter point, the legal and regulatory framework affecting trade among different groups in the sample differs enormously. To truly capture the conditioning effects of regional trade arrangements on export patterns, a greater effort to differentiate between the types of arrangements is necessary (as opposed to the dummy-variable approach taken).

Applying the Results to Other Countries

The economic areas in the currency-union sample are small, with a mean population and per capita real GDP of about one-fifth of that of the whole sample. They are much smaller in comparison to the large industrialized economies, and for the most part they have economic structures that are quite different from the larger countries. For example, they are likely to have much less sophisticated financial structures.

The countries in the sample that are not part of a currency union also differ widely. But of most interest to us are the larger industrialized economies, such as Canada and the major European economies. Are they likely to realize trade gains from joining a currency union of the magnitude suggested by this study? Probably not. These countries already have a large proportion of their domestic production oriented towards trade goods, and a large proportion of that already goes towards prospective (or actual, in the case of the European Economic and Monetary Union (EMU)) partner countries (see Table 1).

Table 1
Export shares (per cent)

	1995	1998
Canada		
Exports/GDP	38	42
Share of exports to the United States	80	86
EU-15		
Exports/GDP	30	32
Share of exports to other EU-15 countries	62	63

Notes: 1995 represents the final year of the author's estimation sample. 1998 is included for purposes of comparison and is the year prior to European monetary union.

Source: IMF Direction of Trade Statistics Yearbook, 2000 and National Accounts of OECD Countries, OECD, Volume II, 1988–98.

The industrialized countries also enjoy deep financial markets and a substantial degree of financial integration, which could be expected to facilitate trade in its own right. For that reason, the author might have found it useful to include some measure capturing the role of financial depth and integration in his analysis.

Other Results

Rose uses the data to produce a number of interesting results. Members of common-currency areas tend to be more specialized (i.e., they have a higher Herfindahl Index for exported goods). Despite greater specialization, which may conceivably lead to a greater incidence of asymmetric shocks, members of a currency union appear to have more tightly synchronized business cycles (although the effect is not large, with a regional trade agreement being more important in this regard). These results are, as indicated above, subject to concerns about causality (i.e., is it the currency union that causes the higher correlations, or vice versa?).

Is there a greater incidence of risk-sharing among members of a currency union? In contrast to the results obtained for trade, the currency-union coefficient in these regressions is typically small and statistically insignificant. In effect, a currency union reduces the domestic "home-bias" effect with respect to trade, but not with respect to risk-sharing. Why this is the case is not clear.

Where Next?

Empirical studies of the effects of currency unions are constrained by the fact that there have been few "new" currency unions and by the fact that existing currency unions were concentrated within small economic units. However, there are now at least two recent, and more relevant, examples: Germany, beginning in the early 1990s, and EMU, begun in 1999. Germany represents a political union, as well, which reduces its usefulness for our purposes; thus, analysis will likely concentrate on the larger EMU.

EMU represents a wealth of potential research opportunities, once the passage of time has led to a sufficient body of data. Unfortunately, like Germany, EMU does not represent a pure example of a currency union, with steps being taken in the direction of a common policy framework and a reduction of regulatory differences. Thus, it will be difficult to disentangle the effects of monetary union from other influences, although that will not prevent researchers from trying.

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General Discussion

John Crow led off the session by noting that he was intrigued by the relative lack of evidence of price integration, and he wondered whether Andrew Rose was surprised by the results as well. Rose responded that he was indeed surprised—and not especially pleased—that the price results on price integration across countries were so negative. He added that because trade is higher among currency-union countries, prices should be more similar and the goods market more integrated.

Crow followed up with a question for Daniel Racette by asking whether the burden of proof in the case of adopting a common currency or dollarization should lie with those who want that change rather than with advocates of the status quo. Racette replied that he agreed entirely. He added, however, that he was disturbed by the disparity in the figures being put forward—about 0.15 per cent of consumption in favour of a flexible rate found in the Macklem et al. paper—compared with those demonstrated by Rose for common currencies. He said that in spite of Rose's impressive figures, however, he remained a strong supporter of the flexible exchange rate.

Charles Freedman asked whether currency unions create or divert trade. Also, does the non-convergence of real exchange rates mean that misalignments are no smaller in currency unions? Rose replied in the affirmative to the latter question. In the case of trade diversion, he argued that it could arise without hurting welfare, since the currency union is removing a barrier. However, his work with Frankel found that common-currency members tend to trade more with other partners, as well as with their common-currency partners.

In response to a query from Robert Leeson about the applicability of his results to larger countries, Rose noted that his other work with Frankel shows that the benefits of currency union flow primarily to the smaller partners. Paul Masson stated that the currency-union examples were mostly small and poor partners linked to a richer and larger pivot country. Rose said that the West African CFA franc zone and the Eastern Caribbean currency association are not formally linked to the french franc and U.S. dollar. They are multilateral currency unions. The results for multilateral currency unions are no different than for those countries that unilaterally adopt the currency of their major trading partner. Dan Ciuriak asked about the effects on growth. Rose and Frankel estimate that greater openness influences growth. Doubling or trebling trade, therefore, can have a large effect. They estimate that if Canada were to unilaterally dollarize, there would be a long-run 20 per cent increase in GDP.

Chris Ragan was concerned about reverse causality: could the effect of currency unions on trade be explained by the fact that the political decision to join a currency union was based on economic variables? Rose thought that the reverse-causality argument is an academically reasonable subject but of no empirical importance. Political scientists have not found any effect of economic variables in the decisions to join currency unions.

Lawrence Schembri wondered whether currency unions could also lead to other policies that might facilitate trade, such as the provision of transport infrastructure. Rose replied that he is unaware of any evidence to support this assertion. Schembri also asked whether the gains from exploiting comparative advantage might be reason for the large trade volumes among common-currency-union members and not the common currency per se. Rose noted that he has controlled for comparative advantage by eliminating country pairs with very large trade volumes to ensure that the results are not excessively dependent on those pairs. Michael Bordo mentioned research by Flandreau showing that the Austro-Hungarian Empire generated high levels of trade among its members and these were relatively large countries.

Session 3: Exchange Rates, Currency Markets, and Trade Flows

The Role of Chartists and Fundamentalists in Currency Markets: The Experience of Australia, Canada, and New Zealand

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Ramdane Djoudad, John Murray,
*Tracy Chan, and Jason Daw**

Introduction

Almost 30 years have passed since the collapse of Bretton Woods, and hopes of resurrecting this system of pegged exchange rates have long since faded. Although many emerging markets continue to operate under a "soft fix," most industrial countries have opted for one of the two extremes—a freely floating or firmly fixed exchange rate.[1] Those at the flexible end of the spectrum have avoided serious difficulty, but have often worried about the excessive volatility and persistent misalignments that are thought to characterize this regime. For large, relatively closed economies, such as Japan and the United States, these erratic episodes are troublesome, but generally tolerable. For small, relatively open economies, such as Australia, Canada, and New Zealand, the prospective problems are much greater. Exports represent a much larger share of their GDP, and wide swings in the exchange rate could destabilize their domestic economies.

In a perfect world, monetary authorities would be able to distinguish between exchange rate movements caused by changing economic fundamentals and those driven solely by speculative whim. In cases where the movement appeared unjustified or excessive, steps could be taken to correct the situation. Unfortunately, the real world is far removed from this ideal state. In the case of small industrial countries, the identification problem that authorities face can be particularly difficult. Many of these countries are commodity exporters and are subject to sudden shifts in economic conditions. Fluctuations in world commodity prices, for example, may require a sharp appreciation or depreciation of the local currency. Efforts to resist these movements would only create additional problems and frustrate the re-equilibration process.

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[1] Only four of the 20 original member countries in the OECD currently operate under an "intermediate" exchange rate regime.

* The authors would like to thank their colleagues for many helpful suggestions and to acknowledge the valuable assistance of Nathalie Lachapelle.

This paper looks at the post-Bretton Woods experience of Australia, Canada, and New Zealand and tries to determine whether past exchange rate movements have been consistent with economic fundamentals. The first half of the paper is devoted to estimating and testing simple error-correction models. Work by Amano and van Norden (1993) and Murray, van Norden, and Vigfusson (1996) has shown that most of the major movements of the Canadian dollar can be explained by four fundamental variables: the Canada-U.S. interest rate differential, the Canada-U.S. inflation differential, the real U.S. dollar price of energy commodities, and the real U.S. dollar price of non-energy commodities. One of the objectives of our paper is to apply similar models to Australia and New Zealand and to see if the same fundamental variables play an important role in explaining the behaviour of their currencies.

The second half of the paper approaches the problem from a somewhat different angle. It uses regime-switching models to capture the interaction of two different types of foreign exchange traders: chartists and fundamentalists. Chartists are assumed to operate on the basis of mechanical trading rules that are linked to past movements in the exchange rate, while fundamentalists, as the name suggests, pay greater attention to economic fundamentals. A number of alternative specifications are tested to gauge the relative importance of each group at different points in time. Vigfusson (1996) and Murray, Zelmer, and Antia (2000) have estimated regime-switching models for Canada and have uncovered some significant but surprising results. According to their estimates, fundamentalists have typically dominated foreign exchange markets during more turbulent periods, while chartists have been active during more tranquil periods.

This paper extends the earlier work on regime-switching models in three important ways. First, it applies the models to two additional currencies—the Australian and New Zealand dollars. Second, it tests a broader range of chartist trading strategies. Third, it estimates the models over a longer sample, which includes the recent crises in Asia, Latin America, and Russia.

The paper is organized as follows. Section 1 provides some background information on the Australian, Canadian, and New Zealand economies, as well as on the past behaviour of their currencies. The actions of the monetary authorities in each of these countries are also briefly described. Section 2 presents the error-correction models that have been developed for the three currencies and compares their performance with that of other exchange rate models. The results are used as inputs to the regime-switching models estimated in section 3. The implications of chartist and fundamentalist behaviour for official intervention in the foreign exchange market are reviewed in section 4. The paper concludes with a summary of the major results and suggestions for future research.

The results that we report are, for the most part, encouraging. They support a "fundamentalist" view of exchange rate determination and are consistent with the Canadian evidence reported earlier. Simple error-correction models are able to explain most of the persistent movements in the Australian, Canadian, and New Zealand dollars. In addition, there is evidence that fundamentalists, rather than chartists, are more active in foreign exchange markets during turbulent periods. Consequently, monetary authorities should be wary of intervening. Flexible exchange rates in Australia, Canada, and New Zealand are generally behaving as theory would predict and are often driven by strong fundamental forces. Any attempt to resist or reverse them is likely to be counterproductive and will simply impose additional costs on the domestic economy.

1 The Three Commodity Currencies

1.1 Background

Australia, Canada, and New Zealand have many common characteristics. All three have open and highly developed economies and rely on commodity exports for a significant portion of their international trade. Although Canada and Australia are obviously much larger than New Zealand, both in a geographical sense and in terms of their populations, most observers would still regard them as "small" from a macroeconomic perspective. With the exception of a few primary products, such as lamb, nickel, and gold, they are unlikely to exert much influence on world demand or supply. They are essentially price-takers.

The population of New Zealand, for example, was only 3.8 million in 1999. Its GDP, expressed in U.S. dollars, was $50 billion, and resource-based commodities accounted for more than 60 per cent of its total exports.[2] These figures clearly represent one extreme, but capture the essential features of all three economies. Canada's population was 30.5 million in 1999 or roughly 10 times the size of New Zealand's, while its GDP was US$650 billion. The U.S. population, in turn, was more than 10 times that of Canada, and the United States clearly dominated all three countries, individually and collectively, in terms of the influence it could exert on the world economy.

Another important feature of Australia, Canada, and New Zealand, from the standpoint of our study, is that all three countries operate under a flexible exchange rate. The movements in each currency vis-à-vis the U.S. dollar are shown in Figure 1. The line representing the Canadian dollar begins in June 1970, just after Canada decided to leave Bretton Woods. The lines for the Australian and New Zealand dollars begin in January 1985 and January 1987, respectively, roughly one to two years after each of these countries moved to a floating-rate system.

The three currencies display considerable volatility and have drifted downwards over time, consistent with the weakness in world commodity prices during this period (see Figure 2). As one might expect, the trade-weighted exchange rate for each country is slightly less variable than its bilateral U.S. dollar rate; however, the two series are highly correlated. The similarity between the trade-weighted and bilateral rates is not so surprising in the case of Canada, since 85 per cent of Canada's exports go to the United States. In the case of Australia and New Zealand, however, one might have expected more divergence. The U.S. share of Australian and New Zealand exports is only 10 per cent and 14 per cent, respectively. The fact that the two series follow such similar time paths is indicative of the number of other trading partners in the Asian region that have elected to peg their currencies, either explicitly or implicitly, to the U.S. dollar.

For convenience, the rest of the analysis is conducted using bilateral exchange rates. The statistical properties of the bilateral and trade-weighted exchange rates are very similar, and preliminary testing using both measures suggests that the results are essentially the same. While a trade-weighted exchange rate might be preferred on theoretical grounds, there is reason to believe that the bilateral rate actually provides a more reliable measure of each country's competitive position. Analyses conducted by Australian academics and by the Reserve Bank of New Zealand (RBNZ) indicate that the trade-weighted indexes understate the importance of the United States for their two economies (see Brook 1994 and Karfakis and Phipps 1999).

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[2] The numbers reported here were taken from the IMF's *International Financial Statistics*, September 2000.

Figure 1
Bilateral exchange rates for Australia, Canada, and New Zealand

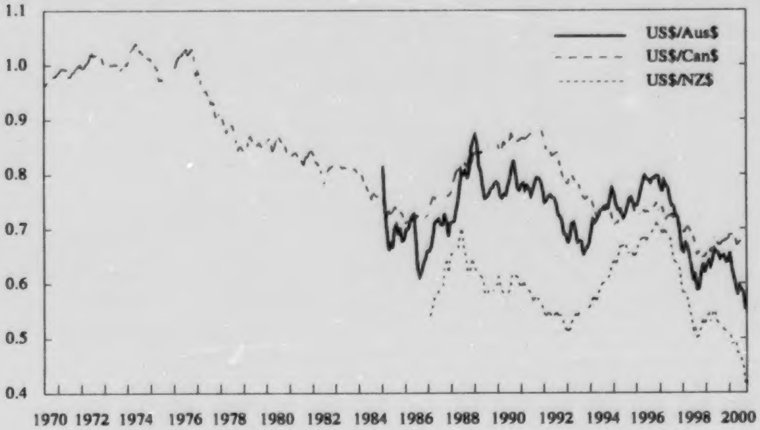
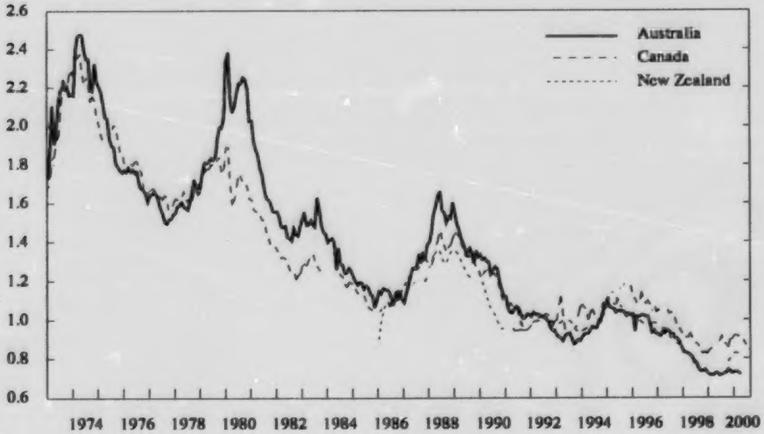


Figure 2
Real non-energy commodity prices for Australia, Canada, and New Zealand



International trade is often denominated and carried out in U.S. dollars even when both parties reside outside of the United States. The same is true for most international financial transactions.

1.2 The Asian financial crisis

The Asian financial crisis[3] provides a dramatic example of how sensitive the Australian, Canadian, and New Zealand dollars are to movements in world commodity prices. Although sales to Asia represent less than 8 per cent of Canada's total exports, the resulting decline in world commodity prices caused the Canadian dollar to depreciate by approximately 12 per cent over the 1997–98 period. The effect on the Australian and New Zealand dollars was even more pronounced. Asia is a much more important trading partner for Australia and New Zealand than it is for Canada, and resource-based commodities represent a larger share of their total exports. As a result, both exchange rates depreciated by about 25 per cent.

The monetary authorities in all three countries understood that a sizable depreciation of their currencies was probably unavoidable. They did not appreciate the severity of the situation, however, until the crisis was well underway. They also questioned whether markets could be trusted to perform the sort of re-equilibrating function they were supposed to, without significant overshooting. The sharp depreciations that each currency experienced in the first few months of the crisis seemed much larger than circumstances warranted. All three central banks, therefore, decided to intervene in an effort to moderate, if not reverse, some of the excessive exchange rate movement.

The Reserve Bank of Australia (RBA) relied exclusively on sterilized intervention and entered the market on only two or three occasions. Interest rates were left unchanged throughout the crisis period. The authorities were worried about the level of the Australian dollar, as well as the speed with which it was falling, but were not prepared to tighten monetary conditions to help support it. Their objective was simply to provide some resistance to the speculative momentum that had developed and to introduce an element of two-way risk in foreign exchange markets. The RBA was careful to time its actions so that its intervention would have maximum effect. It was also willing to risk large amounts of money. If the currency continued to decline after the intervention exercise was complete, the authorities took it as a sign that the move was fundamentally driven and should not be resisted with any additional action.

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[3] The term "Asian financial crisis" is used rather loosely throughout the text to refer to all the financial crises that occurred over the 1997–99 period. They include the collapse of several economies in Southeast Asia in 1997–98, as well as the collapse of the Russian and Brazilian economies in 1998 and 1999.

The RBNZ had similar concerns about the sharp depreciation of its dollar, but reacted differently. It believed that sterilized intervention was ineffective and had not engaged in any traditional intervention activity since 1985. Its primary objective during the early stages of the crisis was to prevent domestic monetary conditions from becoming too loose, and it reacted to the depreciation by aggressively raising official interest rates. Once the RBNZ realized how severe the crisis was, it moved quickly to lower interest rates, but not before the economy had fallen into a deep recession.

The Bank of Canada pursued a policy track that was midway between those of the RBA and the RBNZ. Official interest rates were raised through the latter half of 1997 and again in the summer of 1998, but were reversed before they had any significant impact on economic activity. Intervention in foreign exchange markets was also employed on occasion; however, the amounts involved were modest by Australian standards and were typically followed by more serious monetary policy medicine (i.e., official interest rate adjustments). While the Bank of Canada suspected that the Canadian dollar might have overshot its long-run equilibrium value, its main concern throughout this period was to ensure that exchange-market developments did not destabilize domestic interest rates and push monetary conditions much higher than the economic situation would justify. The Bank hoped that by raising official rates a modest amount, and by offering some resistance through foreign exchange intervention, it could pre-empt a more significant jump in market interest rates.

The fact that the Australian, Canadian, and New Zealand dollars have remained close to the low levels that they reached in 1997–98 (and, in some cases, have fallen below them) suggests that the exchange rate movements observed during the Asian crisis were probably warranted. The error-correction models presented in section 2 are designed to see if this is the case and to determine what factors might have been responsible for the dramatic depreciations.

2 Fundamental Determinants of the Exchange Rate

2.1 The basic error-correction model

The error-correction models that are estimated in this section for Australia, Canada, and New Zealand are based on an equation that was first developed by Amano and van Norden in the early 1990s. Although the original equation contained only four explanatory variables, it was able to track most of the major movements in the Canadian dollar over the 1973M1–92M2 period. It also appeared remarkably stable. All of its coefficients were statistically significant and (for the most part) sensibly signed. It was also able to forecast future exchange rate movements with greater accuracy than a random walk (i.e., it passed the Meese-Rogoff test).

Subsequent testing of this model has confirmed that its superior performance was not an accident or an econometric fluke. It continues to track movements in the Canadian dollar with surprising accuracy and has become an important part of the Bank of Canada's internal forecasting exercise.

The basic Amano-van Norden equation can be written as follows:

$$\begin{aligned}\Delta\ln(rfx) = {} & \alpha(\ln(rfx)_{t-1} - \beta_0 - \beta_c \ln(comtot)_{t-1} \\ & - \beta_e \ln(enetot)_{t-1}) + \Upsilon intdif_{t-1} + \varepsilon_t, \qquad (1)\end{aligned}$$

where: rfx = real US\$/C\$ exchange rate,
$comtot$ = real non-energy commodity terms of trade,
$enetot$ = real terms of trade for energy,
$intdif$ = C-US interest rate differential.

The dependent variable, rfx, is the real value of the US\$/C\$ exchange rate, where the nominal exchange rate has simply been deflated by the consumer price index (CPI) for each country. (Previous work has indicated that it does not make much difference whether the GDP deflator or the CPI is used for this purpose.) The terms of trade for non-energy commodities, $comtot$, is taken from the Bank of Canada's commodity price index and includes all the major non-energy commodities that Canada produces, weighted according to their relative importance.[4] It is deflated by the U.S. CPI to convert it into a real price variable. The same procedure is used to calculate $enetot$, but only energy-related commodities are included in the index. The final explanatory variable is the C-US interest rate differential, $intdif$, which is designed to capture the effects of changes in Canadian and U.S. monetary policies on the value of the real exchange rate. It was originally modelled as the difference between the short-term and long-term interest rate spreads in Canada and the United States:

$$intdif = (i_l^c - i_s^c) - (i_l^{us} - i_s^{us}).$$

More recently, however, the variable has been replaced by the short-term interest rate differentials for the two countries ($intdif = (i_c^s - i_{us}^s)$), since the regression results are essentially the same with either specification.

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[4] Appendix 1 describes the composition of the non-energy commodity price index, as well as the energy price index.

Representative results for the error-correction model are shown in Table 1, estimated with quarterly data over two different sample periods.[5] The parameters display very little movement as the sample is extended, and they retain their statistical significance. Since upward movements in the real exchange rate are associated with appreciations (and downward movements with depreciations), the positive signs on *comtot* and *intdif* indicate that higher prices for non-energy commodities and higher C-US interest rate differentials cause the Canadian dollar to strengthen. Higher energy prices, in contrast, cause it to weaken. While the last effect was not expected when the equation was first estimated, it has proven to be a remarkably robust result. Canada is a small, but significant, net exporter of energy products, and one might have anticipated a positive sign on *enetot*. Various theories have been proposed to explain this anomalous result, but the most convincing relates to Canada's use of energy products. Most Canadian industries, not to mention Canadian households, are intensive users of oil, natural gas, and other energy products. Indeed, recent statistics suggest that Canadians use 50 per cent more energy per dollar of GDP than do Americans. This is an inevitable consequence of Canada's harsh climate and its industrial base, which tends to specialize in energy-intensive production processes. Higher oil prices, such as we are witnessing at the moment, raise the value of our energy exports, but the additional costs that Canada's other industries incur more than offset these gains. The Canadian dollar is, therefore, forced to depreciate in response to the deterioration in our competitive position and the decline in our net worth.

Dynamic simulations of the error-correction model, estimated over the period 1973Q1 to 1999Q4, reveal how well the equation performs (see Figure 3). The simulation begins with the actual value of the exchange rate, but in all subsequent periods its level is determined solely by the estimated parameters and the values of the independent variables. No updating of the dependent variable is allowed. (To facilitate comparisons between the actual and predicted values of the exchange rate, *rfx* has been converted back into nominal terms, using the Canadian and U.S. consumer price indexes.)

While significant differences can be observed between the actual and predicted values of the exchange rate, they are usually eliminated (or at least reduced) within a short period of time. The most important factor contributing to the impressive performance of the equation is the separate recognition given to energy and non-energy price effects. Previous attempts to model the Canadian dollar used a definition of world commodity prices that

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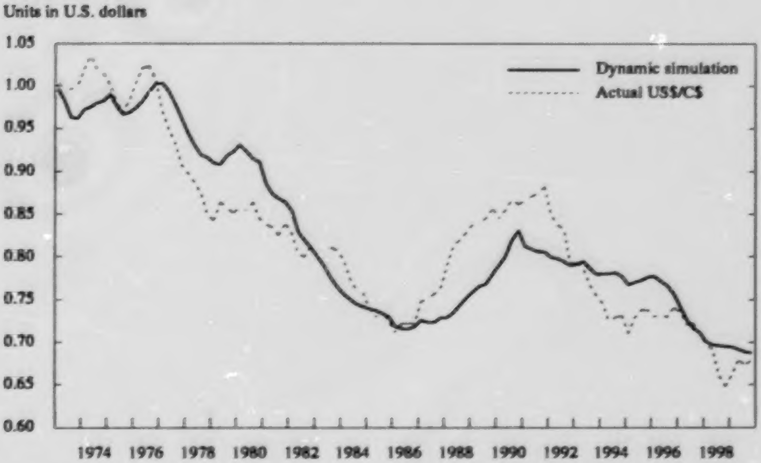
[5] Appendix 2 defines all of the variables that were used in this study and describes the data series from which they were drawn.

Table 1
Error-correction model for the Canadian dollar
Equation (1)

Sample period	**1973Q1 to 1990Q4**		**1973Q1 to 1999Q4**	
Variable	**Coefficient**	***P*-value**	**Coefficient**	***P*-value**
Adjustment	–0.16	0.00	–0.11	0.00
Constant	–0.29	0.00	–0.43	0.00
Real non-energy commodity ($comtot_{t-1}$)	0.24	0.00	0.41	0.00
Real energy ($enetot_{t-1}$)	–0.15	0.00	–0.09	0.03
Interest rate differential ($intdif_{t-1}$)	0.49	0.00	0.58	0.00
R^2	0.23		0.16	

Figure 3
Dynamic simulation for the Canadian dollar
Equation (1)



combined these two effects. As is evident from the regression results, however, the two variables affect the Canadian dollar in very different ways.

The present specification was uncovered only after a great deal of searching, and many different variables and functional forms were tested before Amano and van Norden arrived at this equation. The fact that it has continued to perform so well, several years after it was developed, attests to its reliability, as well as to the exhaustive series of econometric tests that the authors used to verify its properties in 1992.

The four-step procedure that Amano and van Norden followed is documented in their original paper and has been replicated with Australian and New Zealand data in the next two sections of this paper. The first step involves the use of unit-root tests to check for stationarity; the second applies the Johansen-Juselius procedure to determine the number of cointegrating vectors in the data. The third step checks for weak and strong forms of exogeneity and determines whether a simple error-correction model is likely to yield efficient and consistent parameter estimates. The final step tests the residuals of the model for AR (autoregressive) and (autoregressive conditional heteroscedastic) ARCH-type behaviour.

These tests have been applied to the latest version of equation (1) for Canada and have also been used to develop exchange rate equations for Australia and New Zealand. (See Appendix 3 for a more detailed description of the results.) The main features can be summarized as follows and typically hold for all three models.

The two commodity price variables in each equation are generally non-stationary and are integrated of order 1—the same order as the dependent variable, rfx. The interest rate differential, in contrast, is stationary and is therefore placed outside the error-correction term, influencing the short-run movements of the exchange rate but not its long-run behaviour. The Johansen-Juselius tests usually indicate the presence of a single cointegrating vector among the non-stationary variables, although a second cointegrating vector is also found to be marginally significant in some cases. Subsequent testing typically indicates that the first vector includes the exchange rate and that the second vector (if one exists) involves the two commodity price terms.

The results of the exogeneity tests are sensitive to the number of lags included in the estimated equations but often reveal one-way causality running from commodity prices to the exchange rate. Two-way causality, running between exchange rates and commodity prices, is also observed on occasion. Simultaneity is unlikely to pose a problem with regard to the estimation of our equations, since the explanatory variables always enter with a lag. The residuals for the final version of each equation are generally well behaved and, with the exception of the equation for New Zealand, do not appear to suffer from AR or ARCH-type problems. (Some autocorrelation was observed in the New Zealand equation and could not be corrected in the time available. The results for this exchange rate should be interpreted, therefore, with an extra degree of caution.)

2.2 An error-correction model for the Australian dollar

The regression results for the Australian dollar are shown in Table 2. The estimated error-correction model is essentially the same as that for Canada but with two important differences. The first involves the commodity price variables, which have been redefined to reflect the composition of Australia's exports (see Appendix 1); the second relates to the short-term interest rate differential, which is now expressed in real, as opposed to nominal, terms:

$$\begin{aligned}\Delta \ln(rfx) &= \alpha(\ln(rfx)_{t-1} - \beta_0 - \beta_c \ln(comtot)_{t-1} \\ &\quad -\beta_e \ln(enetot)_{t-1}) + \Upsilon intdif_{t-1} + \varepsilon_t, \qquad (2)\end{aligned}$$

where: *rfx* = real US\$/A\$ exchange rate,
comtot = real non-energy commodity terms of trade,
enetot = real energy terms of trade,
intdif = real A-US interest rate differential = $(i_a^s - i_{us}^s)$.

The sample period runs from 1985Q1 to 1999Q4. Although the Australian dollar began floating in December 1983, the starting point for the regression has been shifted by approximately four quarters to allow the exchange rate to adjust to the new regime. As the reader can see, all the parameters (except for the constant term) are statistically significant and have their expected signs. Higher Australian interest rates and higher non-energy prices cause the currency to strengthen, while higher energy prices cause it to weaken—just as they do in Canada. In this case, however, the depressing effect of *enetot* is less surprising, since Australia is a significant net importer of oil, and most of the variation in *enetot* has been related to the price of oil.[6]

The dynamic simulation for the Australian dollar is shown in Figure 4. Some overshooting of the exchange rate is observed over certain periods, but the difference between the actual and predicted values is seldom very large. The Australian dollar appears to have been overvalued in the two years immediately preceding the Asian crisis, for example, but then falls below its "fair market value" once the crisis begins to take hold.

Table 3 reports the results for an alternative specification, based on some of the articles and working papers that have been published on the Australian dollar. (See, for example, Gruen and Wilkinson 1991, Karfakis and Phipps 1999, Koya and Orden 1994, and Tarditi 1996.) Most of these models give a

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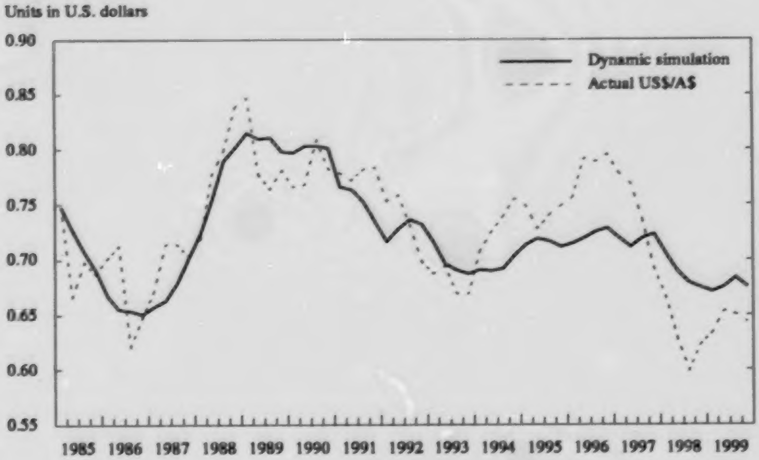
[6] Australia is, nevertheless, a modest net energy exporter. Sales of coal, coke, and other mineral fuels totalled A\$9 billion in 1999, while imports of fuels and lubricants equalled roughly A\$8 billion.

Table 2
Error-correction model for the Australian dollar
Equation (2)

Variable	Coefficient	P-value
Adjustment	–0.29	0.00
Constant	–1.11	0.02
Real non-energy commodity *($comtot_{t-1}$)*	0.69	0.00
Real energy *($enetot_{t-1}$)*	–0.55	0.00
Real interest rate differential *($intdif_{t-1}$)*	0.53	0.04
$\bar{R}^2$	0.21	

Figure 4
Dynamic simulation for the Australian dollar
Equation (2)



prominent role to the terms of trade, as distinct from world commodity prices, and also include the price of gold as a separate explanatory variable.

Attempts to replicate these published results were often unsuccessful, and these efforts failed to uncover any specification that outperformed the error-correction model described above. The new variables were statistically insignificant, and many of the alternative models did not appear to be cointegrated when the sample was extended to include more recent data. The results reported below are taken from one of the more promising models and provide a benchmark with which to judge the results from equation (2).

Table 3
Alternative error-correction model for the Australian dollar
Equation (3)

Variable	Coefficient	*P*-value
Constant	–0.03	0.54
Real exchange rate (rfx_{t-1})	–0.03	0.74
Real gold price (US$/oz.) ($gp_{t-1}$)	0.00	0.01
Terms of trade (tot_{t-1})	–0.11	0.10
Real interest rate differential ($intdif_{t-1}$)	–0.00	0.97
ΔTerms of trade (Δtot_{t-1})	0.002	0.99
$\bar{R}^2$	0.10	

$$\Delta rfx = \beta_0 + \beta_r rfx_{t-1} + \beta_g gp_{t-1} + \beta_t \ln(tot)_{t-1} + \beta_i intdif_{t-1} + \beta_t \Delta \ln(tot)_{t-1} + \varepsilon_t, \qquad (3)$$

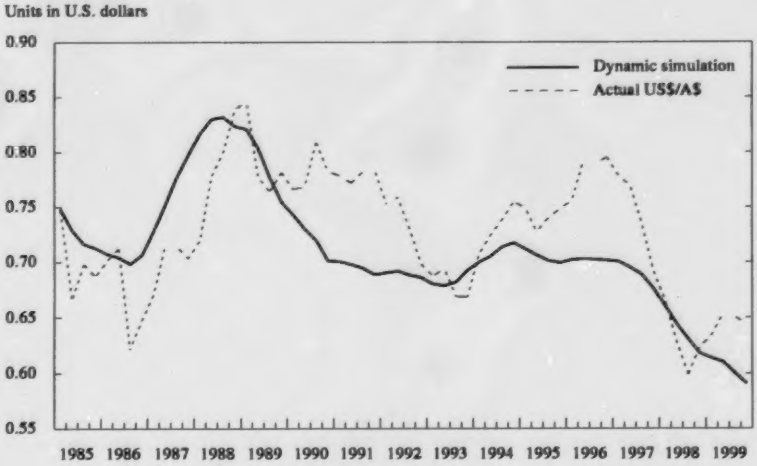
where: rfx = real US$/A$ exchange rate,
gp = real gold price,
tot = terms of trade,
$intdif$ = real A-US interest rate differential = $(i_a^l - i_{us}^l)$.

The price of gold, the terms of trade (expressed in levels), and the interest rate differential are not statistically significant. The dynamic simulation (plotted in Figure 5) also exhibits a much weaker relationship to the actual exchange rate than was observed in Figure 4.

2.3 An error-correction model for the New Zealand dollar

The basic error-correction model described above is also able to track the major movements in the New Zealand dollar. As with the Australian dollar, certain modifications have to be made to reflect differences in the composition of New Zealand's exports and the sensitivity of the New Zealand dollar to different market interest rates. The non-energy price variable has been redefined according to the trade weights shown in Appendix 1, and two interest rate variables have been added to the equation—one for the differential on long-term interest rates and another for the differential on short-term interest rates. Tests on a restricted version of the model, which imposed a common coefficient on the two interest rate terms, were decisively rejected. (Since initial results with equation (4) suggested that the

Figure 5
Alternative dynamic simulation for the Australian dollar
Equation (3)



energy-price term did not have any explanatory power, it was dropped in subsequent runs.)

$$\Delta\ln(rfx) = \alpha(\ln(rfx)_{t-1} - \beta_0 - \beta_c\ln(comtot)_{t-1})$$
$$+ \Upsilon intdif_{1,t-1} + \Phi intdif_{2,t-1} + \varepsilon_t, \qquad (4)$$

where: rfx = real US$/NZ$ exchange rate,
$comtot$ = real non-energy commodity terms of trade,
$intdif_{1,2}$ = real NZ-US interest rate differentials
= $(i_s^{nz} - i_s^{us})$; $(i_l^{nz} - i_l^{us})$.

The sample period begins in 1987Q1, approximately two years after New Zealand decided to float, and ends in 1999Q4. Parameter estimates and test statistics for the final model are shown in Table 4. The results are broadly similar to those in Tables 1 and 2. All the parameters are statistically significant and have their expected signs. The speed of adjustment is somewhat slower than in the Canadian or Australian equations, however, and changes in *comtot* seem to have a much stronger effect on the New Zealand dollar.

Table 4
Error-correction model for the New Zealand dollar
Equation (4)

Variable	**Coefficient**	***P*-value**
Adjustment	–0.11	0.04
Constant	–3.46	0.02
Real non-energy commodity ($comtot_{t-1}$)	0.62	0.04
Real short-term interest rate differential ($intdif_{t-1}$)	0.58	0.04
Real long-term interest rate differential ($intdif_{t-2}$)	–0.79	0.01
$\bar{R}^2$	0.27	

The correspondence between the actual and predicted values of the equation, shown in Figure 6, is not as close as that observed in Figures 3 and 4, but the general pattern is similar. The period immediately preceding the Asian crisis is again associated with an overvalued exchange rate, as judged by the equation, while the period following the crisis is characterized by an undervalued exchange rate.

Since few articles and working papers appear to have been published on the New Zealand dollar, it is difficult to test the performance of our error-correction model against other specifications. One of several experiments that we tried involved replacing the variable for non-energy commodity prices with one for the terms of trade. Koya and Orden (1994) found evidence of a long-run cointegrating relationship between the terms of trade and the New Zealand dollar. However, a similar specification produced insignificant results and a somewhat weaker fit when their model was tested with more recent data (see Table 5 and Figure 7).

$$\Delta 1n(rfx) = \alpha(1n(rfx)_{t-1} - \beta_0 - \beta_c 1n(tot)_{t-1})$$

$$+ \Upsilon intdif_{1,t-1} + \Phi intdif_{2,t-1} + \varepsilon_t, \qquad (5)$$

where: rfx = real US\$/NZ\$ exchange rate,
tot = terms of trade,
$intdif_{1,2}$ = real NZ-US interest rate differentials
$= (i_s^{nz} - i_s^{us});\ (i_l^{nz} - i_l^{us})$.

Based on the results reported above, it would appear that a simple error-correction model is able to explain most of the major movements in all three currencies. Nevertheless, episodes of apparent overshooting and excess volatility are observed in some of the dynamic simulations. Whether this is an indication that other fundamental forces are at work, or simply that destabilizing speculators have been active in the market, is unclear. Many

Figure 6
Dynamic simulation for the New Zealand dollar
Equation (4)

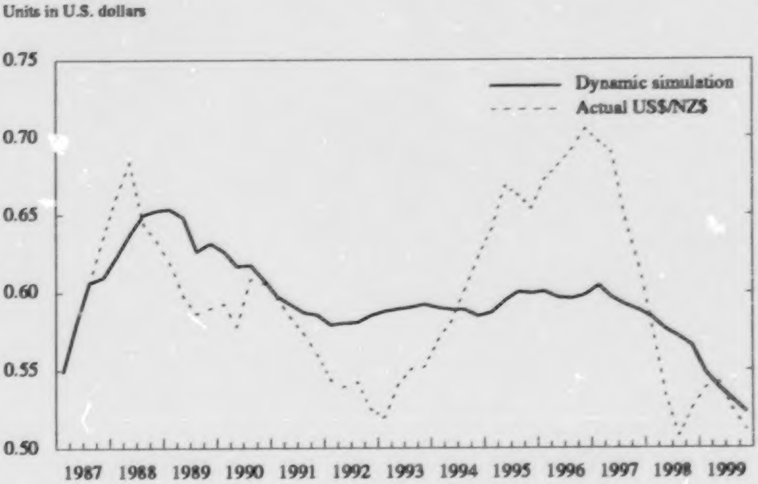
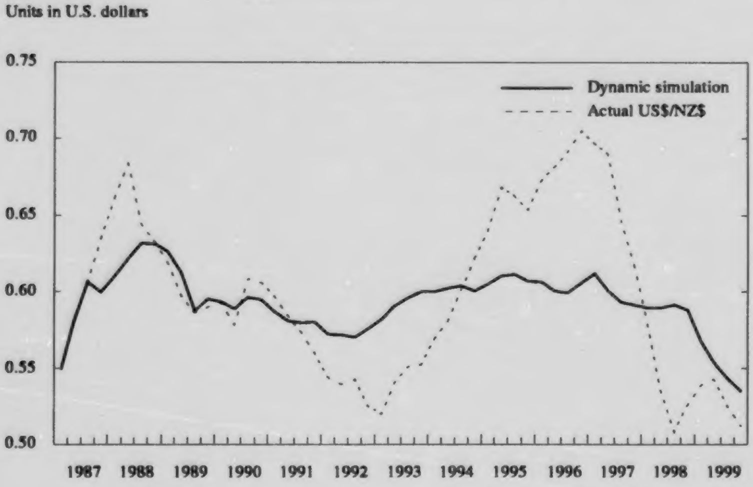


Table 5
Alternative error-correction model for the New Zealand dollar
Equation (5)

Variable	Coefficient	*P*-value
Adjustment	–0.08	0.10
Constant	–0.78	0.00
Terms of trade (tot_{t-1})	2.35	0.24
Real short-term interest rate differential ($intdif_{t-1}$)	1.05	0.00
Real long-term interest rate differential ($intdif_{t-2}$)	–1.30	0.00
$\overline{R}^2$	0.24	

knowledgeable observers are convinced that foreign exchange markets are dominated by chartists and other technical traders, who have little regard for economic fundamentals and who are concerned only with following the latest market trend. The next section of the paper attempts to capture chartists' behaviour in a simple regime-switching model, and to determine whether they have exerted an important influence on the three currencies.

Figure 7
Alternative dynamic simulation for the New Zealand dollar
Equation (5)



3 Regime-Switching Models

The regime-switching models presented in this section assume that there are two types of agents in the foreign exchange market: chartists and fundamentalists. The exchange rate that we observe at any time, t, depends on which group is dominant.[7] Portfolio managers receive advice from both groups and must decide whose recommendations to follow. Chartists, as noted earlier, are assumed to base their recommendations on past movements of the exchange rate. They try to identify emerging trends and turning points in the market and urge portfolio managers to buy or sell a particular currency whenever certain thresholds have been crossed. Fundamentalists realize that exchange rates are subject to destabilizing short-run pressures, but they believe that fundamental forces will eventually push rates back to their long-run equilibrium values. They try to forecast future exchange rate movements with a simple macro model and a few key economic variables.

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[7] Frankel and Froot (1988) were the first economists to develop a formal model of this process.

The maximization problem that portfolio managers face can be written as follows:

$$LLF = \sum_{t=1}^{t} \sum_{t=1}^{t} \rho(s_t) d(e_t | s_t). \tag{6}$$

Equation (6) is a log-likelihood function, and $\rho(s_t)$ is the probability of being in state s at time t, where s represents either a chartist or a fundamentalist regime. Portfolio managers are assumed to weight the forecasts of chartists and fundamentalists in such a way that their chances of correctly predicting the future value of the exchange rate at each point in time are maximized. The expected value of the nominal exchange rate at time t is simply:

$$E\Delta e_{t+1} = \omega_t E\Delta e^f_{t+1} + (1 - \omega_t) E\Delta e^c_{t+1}, \tag{7}$$

where: $E\Delta e$ = expected change in e,
e = log of the nominal exchange rate,
f, c = superscripts indicating fundamentalist and chartist forecasts,
ω = weight assigned to the fundamentalist forecast.

The equations that chartists and fundamentalists use to forecast changes in the exchange rate can be written as:

$$\Delta e^f_t = \lambda^f + \phi(\tilde{e}_{t-1} - e_{t-1}) + \gamma intdif_{t-1} + \varepsilon^f_t,$$

$$\varepsilon^f_t \sim N(0, \sigma^f_t), \tag{8}$$

where: $\tilde{e}$ = fundamentalist forecast of e,
ε^f_t = forecast error (normally distributed with a zero mean and variance $\sigma_t^{\,f}$),

and

$$\Delta e^c_t = \alpha^c + \psi(X) + \Gamma intdif_{t-1} + \varepsilon_t^{\,c},$$

$$\varepsilon^c_t = N(0, \sigma^c_t), \tag{9}$$

where: X = technical trading rule(s) used by chartists to forecast e,
ε^c_t = forecast error (normally distributed with zero mean and variance $\sigma_t^{\,c}$).

Equations (8) and (9) represent the two different states (or regimes) that are presumed to exist in exchange markets. The transition equations that calculate the conditional probability of being in a particular state (given last period's regime) are:

$$\rho(s_t = f|s_{t-1} = f) = \Phi(\alpha_f + \nu_f|s_{t-1} - \tilde{s}_t|), \tag{10}$$

and

$$\rho(s_t = c|s_{t-1} = c) = \Phi(\alpha_c + \nu_c|s_{t-1} - \tilde{s}_t|). \tag{11}$$

The log-likelihood function, the two forecasting equations, and the two transition equations represent the three essential inputs in our Markov regime-switching model. To estimate the model, however, specific functional forms must be substituted for equations (8) to (11). The fundamentalists in our Markov model are assumed to base their forecasts on the exchange rate equations that were developed in section 2. The technical trading rules that chartists use are drawn from the finance literature and are assumed to take one (or more) of the following three forms.

(i) The moving average cross (MAC). This trading rule is based on the behaviour of two moving averages—one calculated over a relatively short time horizon, the other over a somewhat longer interval. Whenever the short-run moving average crosses the long-run moving average from below, a buy signal is generated. (The opposite is true whenever it crosses from above.)[8] For the purposes of our model, the short-term moving average is calculated over a 14-day period (MA14), and the long-run moving average is calculated over a 200-day period (MA200).

(ii) The relative strength index (RSI). This index is used by technical traders to identify overbought and oversold market conditions and is calculated as follows:

$$RSI = 100 - (100/(1 + RS)), \tag{12}$$

where: RS = average number of "up closes" in a given period, divided by the average number of "down closes."

The structure of equation (12) ensures that the RSI will vary between a value of 0 and 100. Arbitrary thresholds, such as 30 and 70, are usually established within this range to identify buying and selling opportunities. (A value lower than 30, for example, might indicate a buying opportunity, while a value higher than 70 might indicate a selling opportunity.) While the RSI enjoys considerable support among technical traders, it is known to produce false signals when markets are moving sharply upwards or downwards.

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[8] Crosses from below are often called "golden crosses," while crosses from above are called "dead crosses."

(iii) The moving average convergence and divergence indicator (MACD). The third trading rule is more complicated than the other two, but has become increasingly popular in recent years. The MACD is a combination of three exponentially smoothed moving averages. The first stage of the calculation is essentially the same as that of the MAC. A short-run moving average (such as 14 days) is subtracted from a long-run moving average (such as 200 days). The difference is then compared with a third line, known as "the signal," which is a short-run exponential average of the MAC. Once again, buy orders are associated with crosses from below, and sell orders are associated with crosses from above.

The transition equations that determine the probability of being in either a chartist or a fundamentalist regime are usually linked to the residuals in one of the forecasting equations. If the fundamentalist equation is used for this purpose, the probability of moving into the fundamentalist regime is assumed to increase with the size ε_t^f. The further the actual exchange rate is from the value predicted by fundamentalists, the more likely it is that the fundamentalist regime will be selected in the next period.

The Markov switching models that we report below are estimated with daily data, using an (expectations-step, maximization-step) EM algorithm and maximum-likelihood techniques (Gauss's maxlik package). The EM algorithm allows the model to approach the maximum much faster than the maxlik package but is slower to converge and does not provide any diagnostic statistics. Since some of the Australian and New Zealand data necessary to estimate the model are available only monthly or quarterly, daily versions of these time series have to be generated using a cubic spline.

3.1 Regime-switching results for Canada

Three different sets of results are reported for Canada. The first set, shown in Table 6, assumes that chartists operate on the basis of a simple MAC. All of the estimated coefficients in the model, with the exception of MA200, are correctly signed and statistically significant. The positive coefficients shown in the first row of Table 6 indicate that the Canadian dollar has a tendency to appreciate whenever the fundamentalist forecast of *e* exceeds its actual value (Fund) or when there is a positive interest rate differential (IRD). The positive sign in the second row, under MA14, suggests that chartists start buying the domestic currency whenever the short-run moving average begins to rise. Unfortunately, the same is also true of MA200. Theory would

Table 6
Parameter estimates for the Markov regime-switching model with the MAC trading rule, Canada (daily data)

Fundamentalist regime	Constant	Fund	IRD	σ^f	l_f	
Estimates	4.67 e-07	0.0817	0.0006	0.0019	1.2995	
P-value	0.49	0.03	0.04	0.00	0.00	
Chartist regime	**Constant**	**MA14**	**MA200**	**IRD**	σ^c	l_c
Estimates	0.0001	0.0237	0.0052	–0.0006	0.0009	1.7016
P-value	0.01	0.07	0.11	0.00	0.00	0.00
	AR(1)	ARCH(1)	Test for higher-order Markov effects		Long-term probability	
Regime 1	0.09	0.54	3.4 e-64		0.31	
Regime 2	0.18	0.80	5.2 e-147		0.69	

predict that the sign on this variable should be negative, but instead it has a value of 0.0052 (although it is statistically insignificant).

Two other points worth noting concern the variance of the chartist and fundamentalist regimes and the long-run probability of being in one regime or the other. According to the figures shown under σ^f and σ^c, fundamentalist regimes in Canada tend to be far more volatile than the chartist regimes. Moreover, the long-run probability of being in a fundamentalist regime is only about half as large as the probability of being in a chartist regime. In other words, chartists appear to dominate the foreign exchange market on most trading days and especially during more tranquil periods. Fundamentalists, in contrast, have a much smaller presence, but typically dominate the market when conditions are more unsettled.

A simple way of characterizing the situation might be as follows. Most short-term activity in the foreign exchange market is guided by technical trading rules, which cause the exchange rate to drift steadily up or down. Once the exchange rate has moved a reasonable distance from its long-run equilibrium value, fundamentalists enter the market and (presumably) earn a profit by pushing it back towards $\tilde{e}$. While the fundamentalist regime is usually associated with increased volatility and disorderly market conditions, it would be a mistake for monetary authorities to intervene. As long as exchange rates are moving in the right direction, maintaining orderly markets should be a secondary consideration. Aggressive intervention would simply slow the re-equilibration process.

Figure 8 plots the actual movements of the Canadian dollar over the 1985–99 period against the probability of being in a fundamentalist regime. (The closer the spikes are to 1.0, the higher the probability of being in a

Figure 8
Probability of a fundamentalist regime, Canada, 1985–99

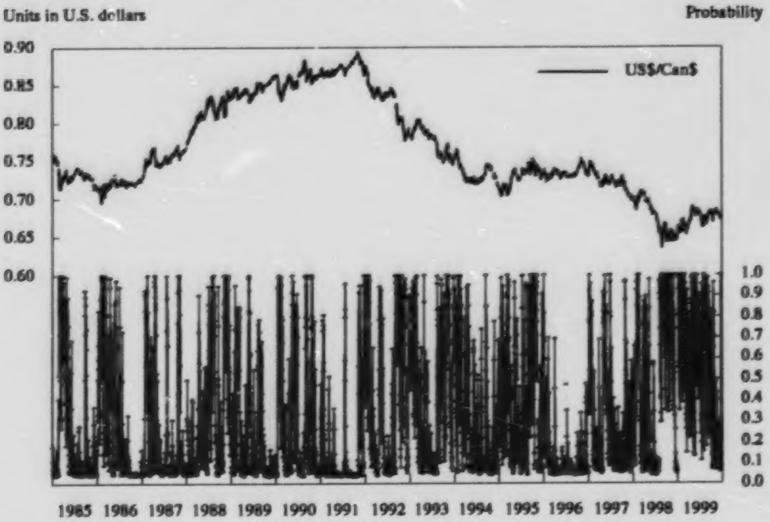


Figure 9
Probability of a fundamentalist regime, Canada, 1995–99

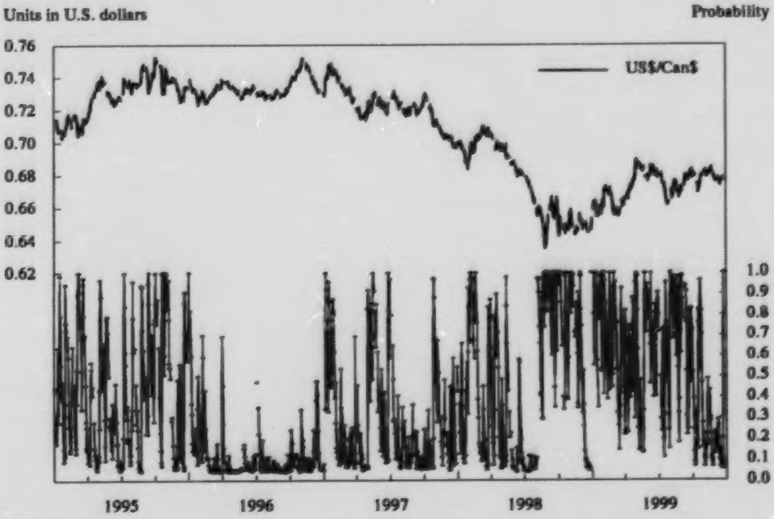


Table 7
Parameter estimates for the Markov regime-switching model with the MAC trading rule, Canada (cubic spline data)

Fundamentalist regime	Constant	Fund	IRD	σ^f	l_f	
Estimates	2.14 e-5	0.0163	–0.0009	0.0019	1.2585	
P-value	0.41	0.04	0.02	0.00	0.00	
Chartist regime	**Constant**	**MA14**	**MA200**	**IRD**	σ^c	l_c
Estimates	0.0001	0.0364	–0.0373	0.0005	0.0009	1.7120
P-value	0.32	0.00	0.10	0.00	0.00	0.00
	AR(1)	ARCH(1)	Test for higher-order Markov effects		Long-term probability	
Regime 1	0.11	0.91	3.63 e-57		0.29	
Regime 2	0.54	0.35	2.91 e-1130		0.71	

fundamentalist regime.) Figure 9 provides a more detailed view of the same series, plotted over the 1995–99 period. A quick glance at either graph confirms the story that was presented earlier. Sharp spikes in the fundamentalist regime are highly correlated with volatile movements in the exchange rate. This is particularly evident during the Asian crisis, but can also be seen on other occasions when the Canadian dollar experienced a significant depreciation. (Appreciations, on the other hand, tend to be more orderly.)

The Markov switching model estimated in Table 7 is very similar to the one in Table 6. The only difference is that some of the data for the fundamentalist forecasts have been generated with a cubic spline, whereas the results in Table 6 are based on actual daily data. All of the important parameters are essentially unchanged, except for the coefficient on MA200, which is now correctly signed and statistically significant at the 10 per cent level. The similarity of the results in Tables 6 and 7 provides some assurance that the estimates for Australia and New Zealand (reported below) have not been affected in any substantive way by the use of the cubic spline.

Table 8 repeats the exercise but replaces the MAC with two other trading rules, the RSI and the MACD. As in the earlier case, the coefficients are all correctly signed and statistically significant. The chartist regime still tends to dominate the market during more tranquil periods, and the long-run probability of being in a chartist regime has risen to 80 per cent. This last number is very close to that reported by Taylor and Allen (1992) in their survey of London foreign exchange traders and is also consistent with the sort of anecdotal evidence that is frequently heard concerning the use of technical trading rules. Taylor and Allen found that 90 per cent of all trading operations in London used some form of chartist or technical trading rule to

Table 8
Parameter estimates for the Markov regime-switching model with the RSI and MACD trading rules, Canada

Fundamentalist regime	**Constant**	**Fund**	**IRD**	σ^f	l_f	
Estimates	–0.0015	0.0050	0.0001	0.0022	1.1016	
P-value	0.00	0.00	0.08	0.00	0.00	
Chartist regime	**Constant**		**MACD**	**RSI**	σ^c	l_c
Estimates	6.05 e-06		–0.2914	–0.0003	0.0009	1.8184
P-value	0.43		0.00	0.00	0.00	0.00
	AR(1)	ARCH(1)	Test for higher-order Markov effects		Long-term probability	
Regime 1	0.14	0.85	3.99 e-53		0.20	
Regime 2	0.38	0.56	1.20 e-133		0.80	

Table 9
Parameter estimates for the Markov regime-switching model with the MAC trading rule, Australia

Fundamentalist regime	**Constant**	**Fund**	**IRD**	σ^f	l_f	
Estimates	–0.0004	0.0177	–0.0006	0.0040	1.1766	
P-value	0.02	0.02	0.28	0.00	0.00	
Chartist regime	**Constant**	**MA14**	**MA200**	**IRD**	σ_c	l_c
Estimates	–0.0003	0.0056	–0.0080	0.0009	0.0017	1.1671
P-value	0.00	0.00	0.00	0.00	0.00	0.00
	AR(1)	ARCH(1)	Test for higher-order Markov effects		Long-term probability	
Regime 1	0.29	0.26	3.6 e-53		0.28	
Regime 2	0.17	0.89	1.03 e-147		0.72	

Table 10
Parameter estimates for the Markov regime-switching model with the RSI and MACD trading rules, Australia

Fundamentalist regime	**Constant**	**Fund**	**IRD**	σ^f	l_f	
Estimates	–0.0004	0.0227	–0.0010	0.0044	1.2461	
P-value	0.03	0.02	0.10	0.00	0.00	
Chartist regime	**Constant**	**MACD**	**RSI**	**IRD**	σ^c	l_c
Estimates	–1.18 e-05	–0.2036	–0.0008	0.0004	0.0019	1.9457
P-value	0.41	0.00	0.00	0.14	0.00	0.00
	AR(1)	ARCH(1)	Test for higher-order Markov effects		Long-term probability	
Regime 1	0.19	0.34	1.5 e-33		0.20	
Regime 2	0.15	0.70	3.12 e-87		0.80	

help guide their activities, especially over short time horizons. As the time frame was extended, however, greater reliance was usually placed on fundamental analysis.

3.2 Regime-switching results for Australia

The regime-switching results for Australia are reported in Tables 9 and 10. They are broadly similar to those for Canada and will not be described in detail. The only difference between the two estimated models in Tables 9 and 10 is the assumption that has been made about the chartists' trading behaviour. Technical traders in Table 9 are assumed to use the MAC, while those in Table 10 rely on a mixture of the RSI and the MACD. The fundamentalist regime has a higher variance than the chartist regime in both models and is also more volatile than the fundamentalist regimes that were reported in any of the Canadian models. However, the long-run probability of being in a fundamentalist regime is generally somewhat lower than in Canada, especially for the MAC versions of the Markov switching model.

Figures 10 and 11, which have been plotted for Australia over the 1987–99 and 1995–99 periods, show results very similar to those reported for Canada. The spikes associated with a fundamentalist regime are usually linked to large downward movements in the exchange rate and are particularly evident during the more volatile periods of the Asian crisis.

3.3 Regime-switching results for New Zealand

The regime-switching results for New Zealand differ from those for Australia and Canada in only one minor respect (see Tables 11 and 12). Some evidence of ARCH-type errors is observed in the residuals for the chartist regimes. Allowing chartists to use different trading strategies does not seem to change the results in any significant way. Substituting the RSI and the MACD trading rules for the MAC reduces the probability of being in a fundamentalist regime but leaves most of the parameter values unchanged.

Figures 12 and 13 present the same story that we saw before, with fundamentalists clearly dominating the exchange market in more turbulent periods. Although the statistical properties of the models for New Zealand might cause some concern, the broad qualitative results reported for this country are unlikely to change once these problems have been corrected.

Table 11
Parameter estimates for the Markov regime-switching model with the MAC trading rule, New Zealand

Fundamentalist regime	**Constant**	**Fund**	**IRD1**	**IRD2**	σ^f		l_f
Estimates	–0.0005	0.0255	–0.0025	0.0058	0.0048		1.0619
***P*-value**	0.04	0.10	0.21	0.05	0.00		0.00
Chartist regime	**Constant**	**MA14**	**MA200**	**IRD1**	**IRD2**	σ^c	l_c
Estimates	–0.0004	0.0060	–0.0076	0.0070	–0.0071	0.0016	1.6531
***P*-value**	0.05	0.20	0.15	0.00	0.02	0.00	0.00
	AR(1)	ARCH(1)	Test for higher-order Markov effects		Long-term probability		
Regime 1	0.18	0.06	1.15 e-45		0.25		
Regime 2	0.20	0.43	3.36 e-132		0.75		

Table 12
Parameter estimates for the Markov regime-switching model with the RSI and MACD trading rules, New Zealand

Fundamentalist regime	**Constant**	**Fund**	**IRD1**	**IRD2**	σ^f		l_f
Estimates	–0.0004	0.0251	–0.0049	0.0086	0.0049		1.0393
***P*-value**	0.08	0.06	0.20	0.03	0.00		0.00
Chartist regime	**Constant**	**RSI**	**MACD**	**IRD1**	**IRD2**	σ^c	l_c
Estimates	–0.0001	–0.0007	–0.2724	0.0069	–0.0075	0.0016	1.6636
***P*-value**	0.05	0.00	0.00	0.01	0.03	0.00	0.00
	AR(1)	ARCH(1)	Test for higher-order Markov effects		Long-term probability		
Regime 1	0.14	0.06	6.75 e-38		0.24		
Regime 2	0.34	0.13	1.78 e-126		0.76		

4 Implications for Foreign Exchange Market Intervention

Taken at face value, the results from sections 2 and 3 would seem to suggest that monetary authorities should be extremely cautious about intervening in foreign exchange markets. Most of the observed movements of the Australian, Canadian, and New Zealand dollars appear to have been driven by economic fundamentals as opposed to destabilizing speculation, and there is very little evidence of significant overshooting. Official intervention is usually undertaken with a view to maintaining orderly markets and keeping exchange rates close to their equilibrium values. But if exchange rates seldom deviate from their equilibrium values, and market volatility is

Figure 10
Probability of a fundamentalist regime, Australia, 1987–99

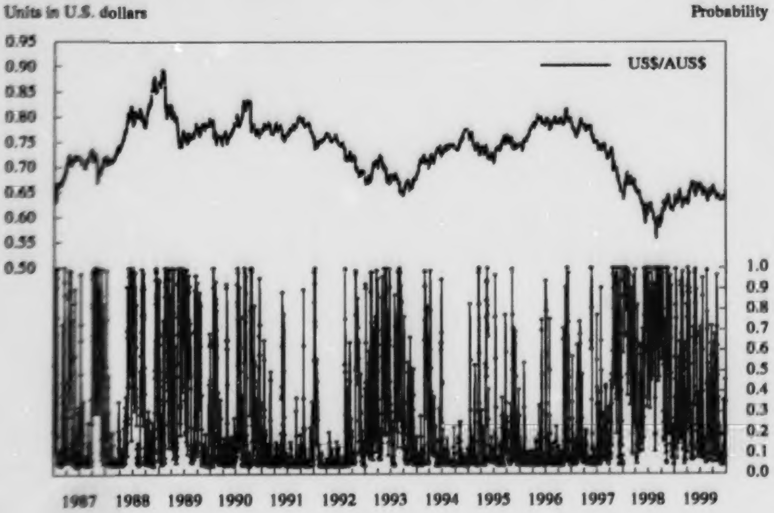


Figure 11
Probability of a fundamentalist regime, Australia, 1995–99

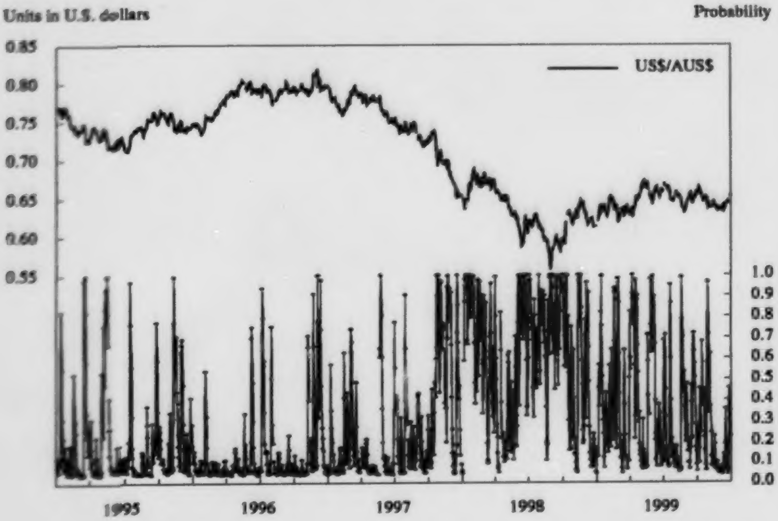


Figure 12
Probability of a fundamentalist regime, New Zealand, 1987–99

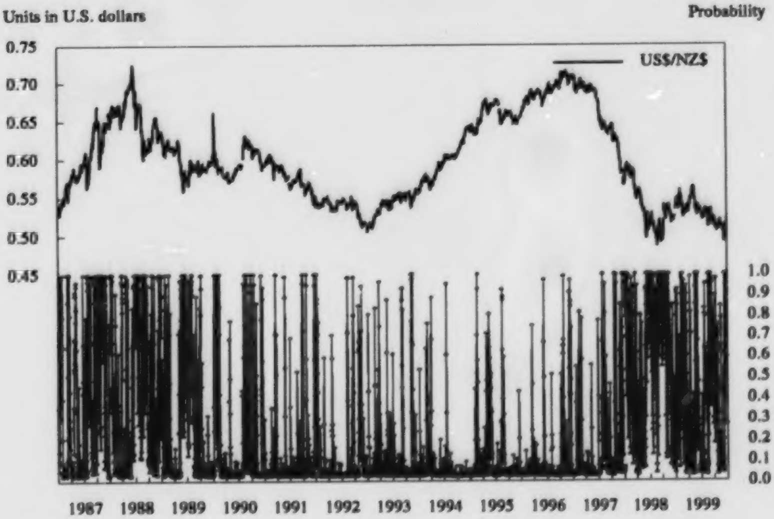
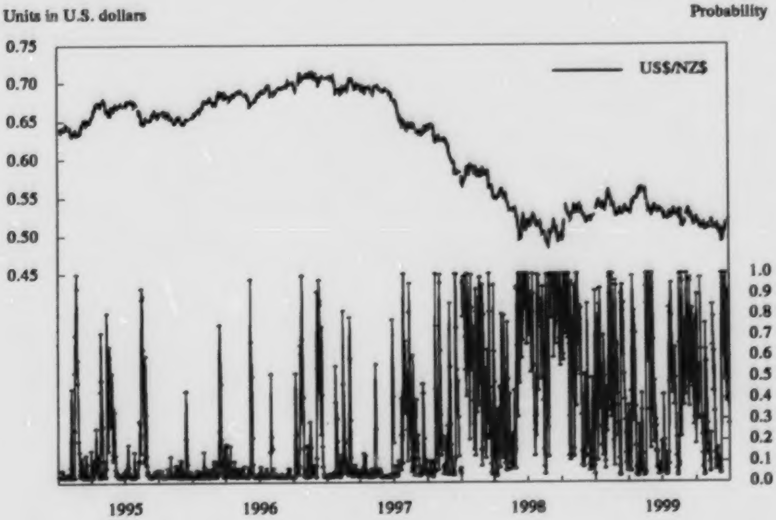


Figure 13
Probability of a fundamentalist regime, New Zealand, 1995–99



typically associated with the stabilizing activities of fundamentalists, these arguments would appear to lose most of their validity. A more relaxed, laissez-faire attitude towards intervention would seem to be called for in the case of these three currencies.

Of the three intervention strategies reviewed in section 1, those of the RBA appear to have offered the least resistance to exchange rate movements. Intervention was initiated on only two or three occasions during the Asian crisis, and less importance was attached to defending the external value of the currency. The Australian authorities generally assumed that their currency was moving for a reason and were not prepared to take any offsetting action. The evidence from section 3 indicates, however, that even this more light-handed touch may have had unfortunate consequences. To the extent that fundamentalists rather than chartists were more active in the Australian market during these turbulent periods, the Australian interventions may have inadvertently delayed necessary adjustments in the exchange rate.

The RBNZ pursued a much more aggressive strategy than the RBA over most of the sample period. Through the first half of the 1990s, exchange rate adjustments were viewed as a way of controlling domestic inflation. Official interest rates would be raised or lowered whenever inflation threatened to move outside the RBNZ's target bands. These interest rate changes were expected to strengthen or weaken the exchange rate and, owing to the open nature of the New Zealand economy, exert a direct influence on consumer prices. The RBNZ soon realized, however, that attempts to control the short-run behaviour of the CPI through regular adjustments in the exchange rate could lead to problems of instrument instability. A new monetary policy strategy was introduced, therefore, based on the monetary conditions index (MCI). According to this strategy, the RBNZ would establish a medium-term path for the MCI, designed to keep the domestic economy in balance. Official interest rates were used to rebalance the index any time an unexpected shift in the exchange rate pushed the MCI off course. Fundamental shocks, which required a change in the exchange rate and a new MCI track, would not be resisted, but portfolio shifts and other unsettling disturbances would be automatically offset. Unfortunately, the RBNZ was inclined to treat most shocks as portfolio shifts. Consequently, more resistance was offered at the start of the Asian crisis than was probably warranted. The evidence from the Markov switching models for New Zealand suggests that this was not an unreasonable assumption on most trading days, since the long-run probability of being in a chartist regime is typically much higher than being in a fundamentalist regime. During volatile periods, however, the reverse is true. With the benefit of hindsight, it is easy to see that most of the exchange rate movements during the Asian crisis were based on economic fundamentals and should have been accommodated (or perhaps reinforced) rather than resisted.

The Bank of Canada, as noted earlier, typically reacted with greater vigour than the RBA, but with less enthusiasm than the RBNZ. It used a combination of sterilized intervention and interest rate adjustments to respond to exchange rate movements through much of the sample period. Although sterilized intervention was often undertaken according to a fixed rule, interest rate adjustments were always applied in a more discretionary manner. In periods of evident instability, such as the Asian crisis, the objective was often to guard against tighter rather than easier monetary conditions. Official interest rates would occasionally be raised in response to a sharp depreciation of the Canadian dollar, even when the movement appeared justified. These adjustments in the Bank Rate were designed to calm financial markets by offering some support for the currency, thereby preventing an even larger increase in market interest rates. The issue of chartists versus fundamentalists—and which regime was dominant at different points in time—was essentially irrelevant. As long as an exchange rate movement was regarded as potentially destabilizing, some offsetting action was deemed necessary.

In retrospect, it appears that the exchange rate movements in Australia, Canada, and New Zealand were often driven by fundamental forces, and less resistance would have been appropriate. It is impossible to know, however, what would have happened if different intervention strategies had been followed. Controlled experiments cannot be conducted in macroeconomics. Ultimately, these actions must be based on judgment and gut instinct. The evidence in sections 2 and 3 should be regarded as simply suggestive, therefore—a modest caution against more aggressive and frequent foreign exchange market intervention.

Conclusion

The main objective of this paper was to examine the recent behaviour of the Australian, Canadian, and New Zealand dollars, and to determine whether there was any evidence of significant overshooting and instability. Simple error-correction models were developed and tested in the first part of the paper. The results suggested that all three currencies were sensitive to changes in world commodity prices and that a few fundamental variables could account for most of the observed movements in each of these currencies over the post-Bretton Woods period.

The second part of the paper examined the activities of chartists and fundamentalists in foreign exchange markets. Regime-switching models were constructed and used to determine the relative importance of these two groups at different points in time. The results for all three currencies were once again very similar. While there was strong evidence of chartist-type behaviour throughout the 1985–99 period, most of the erratic movements in the Australian, Canadian, and New Zealand dollars seem to have been driven by fundamentalists. Chartists were responsible for most of the trading activity in foreign exchange markets, but tended to dominate markets during more tranquil periods. Fundamentalists, on the other hand, appeared to enter the market in a more selective and episodic manner and exerted a greater influence during more turbulent times.

While these results were not expected when the study was undertaken, they are consistent with earlier work by Amano and van Norden (1993); Vigfusson (1996); Murray, van Norden, and Vigfusson (1996); and Murray, Zelmer, and Antia (2000). Our main conclusion is that most exchange rate movements in Australia, Canada, and New Zealand are benign and should not be resisted. They are usually driven by economic fundamentals and represent necessary market corrections. Efforts to smooth exchange rate movements through sterilized intervention and interest rate adjustments are unlikely to be successful, therefore, and may simply reduce market efficiency and stability.

Future research by the authors will concentrate on the following topics. First, we would like to correct the statistical problems associated with the equations for New Zealand. The results that we obtained for the "kiwi" were encouraging and similar to those for the other two currencies. Additional work will be required, however, before these results can be used with any confidence. Second, we would like to improve the performance of our error-correction models by including additional explanatory variables in each equation. Our objective in this paper was not to find the best specification for each currency, but rather to identify a small set of fundamental variables that seemed to work in all three cases. There is no reason to believe that the three or four fundamental variables that were identified in section 2 exhaust all useful possibilities. Third, it would be interesting to test a somewhat larger set of chartist trading rules in our regime-switching models. The parameter estimates for the MAC, RSI, and MACD trading rules were all statistically significant and give us some assurance that the results are reasonably robust. (Those with more experience in this area may still be unconvinced, however.) Fourth, the software used to estimate the regime-switching models in section 3 can be extended to capture the effects of more than two regimes. Some of the test results reported above suggest that Markov models allowing three or more states might provide a better representation of real-world behaviour.

Appendix 1

Table A1.1
Composition of non-energy commodity price indexes

Canada	%	Australia	%	New Zealand	%
Barley	1.8	Barley	2.4	Kiwi fruit	3.7
Canola	2.0	Rice	0.8	Wholemeal MP	10.6
Corn	1.2	Sugar	5.8	Skim MP	3.7
Wheat	8.5	Wheat	13.2	Apples	3.1
Beef	9.4	Beef	9.0	Fish	6.7
Hogs	4.9	Cotton	3.3	Casein	6.7
Cod	0.01	Wool	17.9	Butter	6.5
Lobster	0.5	Gold	19.4	Cheese	8.3
Salmon	0.6	Aluminum	8.9	Beef	9.4
Gold	4.3	Copper	3.1	Lamb	12.5
Silver	0.9	Zinc	1.8	Wool	7.7
Aluminum	4.6	Nickel	2.5	Skins	1.6
Copper	4.5	Iron ore	10.6	Aluminum	8.3
Nickel	3.7	Lead	1.3	Sawn timber	4.6
Zinc	4.2			Logs	3.5
Potash	2.0			Pulp	3.1
Sulphur	1.4				
Lumber	13.8				
Newsprint	12.8				
Pulp	18.9				
TOTAL	100		100		100

Table A1.2
Composition of energy commodity price indexes

Canada	%	Australia	%	New Zealand	%
Crude oil	62.3	Crude oil	15.7	Crude oil	100
Natural gas	29.9	Natural gas	11.1		
Coal	7.8	Coal	73.2		
TOTAL	100		100		100

Appendix 2

Exchange rates

— monthly exchange rates from International Financial Statistics (IFS)
— daily exchange rates from Bank of Canada internal database

Consumer price indexes (all items)

— Canada (Statistics Canada)
— United States (Data Resources Limited/McGraw-Hill)
— Australia (OECD main economic indicators)
— New Zealand (OECD main economic indicators)

Interest rates (monthly or quarterly)

— Canada, 90-day prime corporate paper rate (Statistics Canada)
— United States, 90-day commercial paper rates (Statistics Canada)
— United States, T-bill rate: discount on new issues of three-month bills (IFS)
— United States, long bond: 10-year constant maturities (IFS)
— Australia, 90-day bank-accepted bills (OECD main economic indicators)
— Australia, long bond: secondary market yields on non-rebate bonds with maturity of 10 years. Yields are calculated before brokerage and on the last business day of the month (IFS).
— New Zealand, 90-day bank bills (OECD main economic indicators)
— New Zealand, long bond: rate on the five-year "benchmark" bond, a specific bond selected by the Reserve Bank to provide a representative five-year government bond rate (IFS)

Commodity prices

— Canada, non-energy commodity price index (Statistics Canada)
— Canada, energy price index (Statistics Canada)
— Australia, non-energy commodity price index (used weights from the RBA and constructed a non-energy index by re-weighting). Price data used for commodities were IFS, and the Bank of Canada internal database was used for barley.
— Australia, energy commodity price index (used weights from the RBA and constructed an energy index by re-weighting). Price data used for commodities were from IFS and Bank of Canada internal database for the following commodity: natural gas.
— New Zealand, non-energy commodity price index (memorandum: Australia and New Zealand Banking Group Limited (ANZ) commodity price index). The New Zealand dollar index was converted to US$ by using the quarterly average of the NZ$/US$ exchange rate.

Gold price

— *Globe and Mail Report on Business* (US$/oz.)

Exports

— Canada (IFS)
— Australia (IFS)
— New Zealand (IFS)

Imports

— Canada (IFS)
— Australia (IFS)
— New Zealand (IFS)

Industrial production

— United States (OECD main economic indicators)

Appendix 3

Unit-root tests

Two different tests were used to check for stationarity in the *rfx*, *comtot*, *enetot*, and *intdif* time series—the Adjusted Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. The optimal lag length for each test was selected according to the procedure suggested by Campbell and Perron (1991).

Table A3.1
Unit-root tests, Canada[a]

Period	1973Q1 to 1999Q4	
	ADF[a]	PP[a]
comtot	–2.1305	–1.2382
enetot	–1.5932	–2.0210
rfx	–1.6066	–0.8871
intdif$_1$	–1.8371	–2.9433**

a. **: 5%.

Table A3.2
Unit-root tests, Australia[a]

Period	1973Q1 to 1999Q4		1985Q1 to 1999Q4	
	ADF	PP	ADF	PP
comtot	–1.4300	–1.1578	–1.4178	–0.8115
enetot	–1.3076	–0.9929	–1.4680	–2.2432
rfx	–2.2239	–1.5182	–2.6095*	–1.6454
intdif[b]	–2.9813**	–8.0578**	–2.6006*	–4.5726**
intdif[c]	–2.6736*	–8.4870**	–3.2509**	–4.9839**

a. *: 10%, **: 5%.
b. *intdif*$_1$ — real T-bill differential.
c. *intdif*$_2$ — real long-term differential.

Table A3.3
Unit-root tests, New Zealand[a]

Period	1987Q1 to 1999Q4	
	ADF	PP
comtot	-2.2126	-1.1130
rfx	-1.9207	-2.3387
intdif[b]	-6.9396**	-7.0041**
intdif[c]	-3.9392**	-6.8980**

a. **: 5%.
b. *intdif*$_1$ — real T-bill differential.
c. *intdif*$_2$ — real long bond differential.

The PP test results for Australia, Canada, and New Zealand cannot reject the presence of a unit root in *rfx*, *comtot*, and *enetot*. The same is true for the ADF test results, except for *rfx* in Table A3.2 over the period 1985Q1–99Q4. When the sample is extended back to 1973Q1, however, the results for both tests are consistent.

Although some variability is observed in the test statistics for the *intdif* terms in Tables A3.1 to A3.3, the unit-root hypothesis can usually be rejected. The one exception is the ADF test for Canada.

Cointegration tests

Cointegration was tested with the Johansen-Juselius procedure, using the max and trace test statistics.

Table A3.4
Cointegration tests

	Canada 1973Q1–1999Q4		Australia 1985Q1–1999Q4		New Zealand 1987Q1–1999Q4	
r =	max	trace	max	trace	max	trace
0	22.88**	35.16**	20.69*	37.63**	18.23**	21.82**
1	7.25	12.27	10.81	16.94	3.59	3.59
2	5.02	5.02	6.13	6.1		
	P-value		*P*-value		*P*-value	
LM(1)	0.92		0.62		0.62	
LM(4)	0.29		0.30		0.30	

a. **: 5%.

The existence of less than one cointegrating vector can be rejected for all three countries. Further testing suggests that it includes each of the non-stationary variables (*rfx*, *comtot*, and *enetot*).

Specification tests for the error-correction models

LM tests were used to check for first- and second-order autocorrelation, and the ARCH tests were used to check for autoregressive conditional heteroscedasticity.

Table A3.5
Specification tests for error-correction models, *p*-values

	Canada 1973Q1–1999Q4	Australia 1985Q1–1999Q4	New Zealand 1987Q1–1999Q4
LM(1)	0.62	0.92	0.49
LM(2)	0.84	0.32	0.42
ARCH(1)	0.63	0.64	0.57
ARCH(2)	0.86	0.40	0.52

Note: These tests were done using a model that included a lagged dependent variable.

None of the test statistics indicates a problem in the three error-correction models. While some signs of higher-order autocorrelation were observed in the case of New Zealand (not shown in Table 5), the residuals reported here were all well-behaved.

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Discussion

Gregor Smith

The impressive study by Djoudad, Murray, Chan, and Daw examines two statistical models of the real exchange rate. The first model, which is linear and uses quarterly data, can be written as:

$$\Delta r(t) = \beta o - \alpha[r(t-1) - \beta c(t-1)] + \gamma i(t-1) + \varepsilon(t),$$

where my simple notation has r as the log real exchange rate, c as a vector of real commodity prices, and i as the interest differential.

I will focus on the statistical and policy aspects of their work, and leave the interpretation of the effects of the two commodity prices to others. Features of their specification and results include the following.

(i) This model is written as a forecasting equation, not as a conventional error-correction mechanism, so its good fit is remarkable. However, if the goal is to explain past movements in the real exchange rate, then the use of current-period regressors might well lead to an even better fit.

(ii) The results for Canada display the forward premium anomaly: $\gamma > 0$, so a high interest rate currency tends to appreciate.

(iii) The authors find that r and c are cointegrated, with slow adjustment.

(iv) The equation is quite stable over time for Canada.

(v) The equation fits better for Australia than do the equations constructed at the Reserve Bank of Australia. Finding an equation that fits for one country over time is an accomplishment. But successfully fitting the same form of equation for other countries is that much more striking.

Perhaps this resilient statistical model could also be tried on small open economies that have adopted a fixed nominal exchange rate with their largest trading partner, since it applies to the real exchange rate. Possible candidates are Canada in the 1960s or the Netherlands.

While the authors' equations fit very well indeed, I do have a suggestion about the reporting of their findings. Their Figures 3 to 7 illustrate dynamic simulations, which show persistent gaps between the actual real exchange rates and the simulated values. But dynamic simulations use a strange information set. In predicting $r(t)$, one uses $c(t-1)$ and $i(t-1)$, but $r(0)$. This information set appears to artificially exclude the recent history of the real exchange rate.

To clearly see the effect of this reporting style, I created a simple simulation and generated data in the following way:

$$\Delta r(t) = 0.3 - 0.14[r(t-1) - c(t-1)] + 0.2\Delta c(t) + 0.7\varepsilon(t),$$

$$c(t) = 0.9c(t-1) + \eta(t),$$

with $\varepsilon(t)$ and $\eta(t)$ pseudo-standard normal. In this simulation laboratory, we know exactly what error-correction mechanism to fit. When I fitted this same form of equation to 100 simulated observations, I found an R-squared and an adjustment speed similar to those in the data. And there was no significant residual autocorrelation, just as the authors found in the historical data.

Figure 1 shows the simulated data (thin line) and the fitted values (thick line), and the fit is very good. Figure 2 shows the impression created by a dynamic simulation, which uses recent observations on the variable *c*, but only the starting value for *r*. Again, the thin line indicates the actual values, while the thick one now shows the dynamic simulation. My point is that the persistent differences between the two lines in Figure 2 are artifacts of the use of dynamic simulation. They are not evidence of bubbles, overshooting, or missing chartists. The underlying cause of this persistence is that multistep forecast errors are autocorrelated, even if one-step forecast errors are not.

The second model the authors examine is nonlinear and estimated in daily data. I think of this, partly, as a specification test. If the model linking the real exchange rate to fundamentals also works well at the daily frequency, the added possibility of switching to moving averages will not matter statistically. But the authors find that this added feature does matter and that there are many switches, with the moving averages dominating during quiet periods. This is a significant discovery, because they have good daily data on the fundamentals (commodity prices and interest rates) in the Canadian case, yet the chartist variables remain important.

Figure 1
ECM fitted values
(thick line)

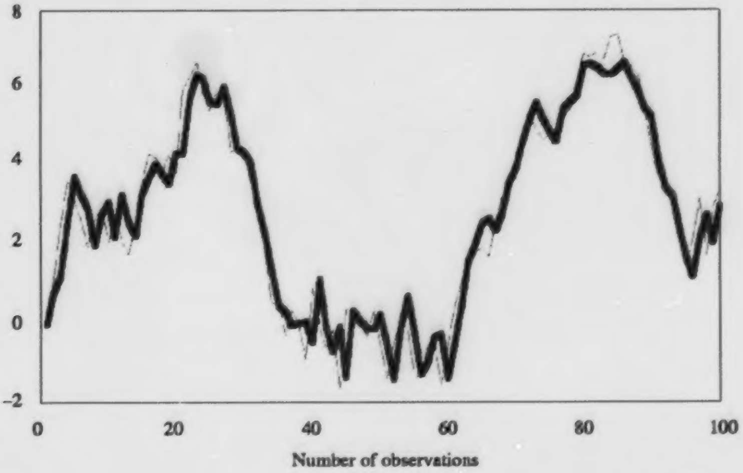
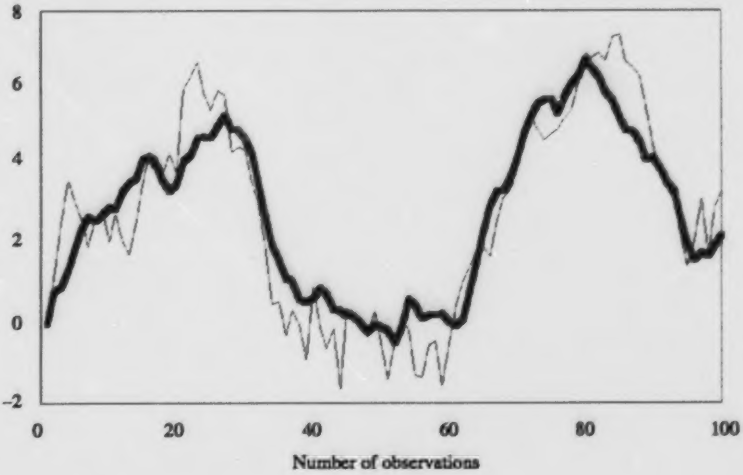


Figure 2
Dynamic simulation
(thick line)



The next step in this research could be the creation of a model in which several types of traders, along with the central bank, participate simultaneously in the foreign exchange market. Such a model might not lead to a simple econometric equation, but its predictions could be studied by simulation.

My final comments relate to policy. The authors suggest that many of the swings in real exchange rates are driven by commodity prices and thus are not signals of the need for intervention. But the international interest rate differential is included in both types of models (and both regimes) they consider. Since the differential is a rough indicator of the policy stance, it is clear that policy does matter, and that it can speed or slow adjustment to the path warranted by commodity prices alone. So, while the authors stress what policy should not do, I think their findings may also shed light on some of what policy has done historically.

For example, in their data for Canada, the correlation between the real exchange rate, $r(t)$, and the interest rate differential, $i(t)$, is 0.45. Meanwhile, the correlation between their estimate of $r(t) - \beta c(t)$ and $i(t)$ is much higher: 0.70. Here I have used their estimates of β, and the vector $c(t)$ includes both commodity prices that they include in their model.

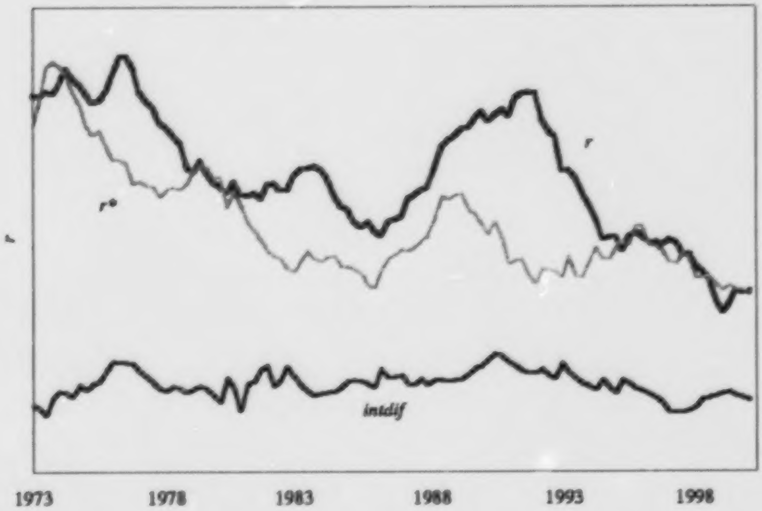
Another way to report this finding is to graph the log real exchange rate along with the linear combination of commodity prices with which it is cointegrated and to show the interest differential in the same graph. Figure 3 does this for Canada. Please note that this figure uses the historical data, with dates shown on the horizontal axis. The combination of commodity prices is labelled r^*, while the interest differential is labeled *intdif*.

Figure 3 has two interesting features. First, the real exchange rate seems to have been adjusting from above towards the path warranted by real commodity prices. In their data definitions, an increase in r is an appreciation. Therefore, the figure suggests that the Canadian dollar has generally been overvalued. Perhaps this pattern is natural in a time of declining commodity prices, but it is worth noting anyway.

The other feature is that periods when the real exchange rate was above the path given by commodity prices were periods when the interest differential was high. Simply put, that creates the impression that monetary policy was slowing down the adjustment of the real exchange rate to its long-run path during these periods.

I am not describing a history of Canadian monetary policy, and the authors certainly aren't, either. The goal of policy has not been to smooth the adjustment of the real exchange rate to shocks, and *intdif* is not a pure measure of policy. But this role for *intdif* may make it difficult to argue that

Figure 3
Canadian real exchange rate
(with long-run fundamentals)



movements in the real exchange rate are driven largely by commodity prices. Gerlach and Smets (2000) have also interpreted statistical evidence to suggest that Canadian monetary policy has reacted to the exchange rate.

I suggest that this correlation might tell us something about the effects of past monetary policy. And perhaps historical data on sterilized intervention could be included in these statistical models to determine whether it, too, has affected these real exchange rates.

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Trade Flows, Prices, and the Exchange Rate Regime

Philippe Bacchetta and Eric van Wincoop

Introduction

It is commonly held that trade flows are enhanced if a country switches from a floating to a fixed exchange rate regime. This is one of the main motivations for exchange rate stabilization in regional trade blocks, such as the European Union. The argument is that exchange rate volatility increases the risk of buying and selling in foreign countries. While this explanation based on risk aversion has intuitive appeal, its validity needs to be examined in a consistent framework. In particular, one must consider the overall macroeconomic uncertainty faced by firms and households and how this is affected by the choice of exchange rate system. In this paper, we will do so within the context of a simple two-country general-equilibrium set-up, since it is not sufficient to analyze single individual firms or consumers to understand aggregate trade.

Most international macroeconomics models are not suited to analyzing these issues. For example, in the standard models of the Mundell-Fleming type, the impact of exchange rate risk cannot be analyzed, since the aggregate behavioural equations are ad hoc, and individual decisions are not modelled. There is also a literature that examines individual firms facing exogenous exchange rate fluctuations. But this partial-equilibrium approach is inadequate, since it does not consider the overall macroeconomic risks that affect firms and households and that also affect the exchange rate itself.[1]

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[1] See Côté (1994) for a review of the literature.

The extent to which exchange rate fluctuations affect firms depends crucially on their pricing strategy. When exporters set prices in their home currency, they are not directly affected by the nominal exchange rate through the price received for their goods. We will call this case PCP (producer currency pricing). Nevertheless, this strategy is not widely used in practice. It would imply that prices in local currency move one-to-one with the nominal exchange rate (i.e., that the law of one price holds). Most empirical evidence shows that the pass-through from exchange rate to prices is gradual and incomplete (see, for example, Goldberg and Knetter 1997, for a survey) so that purchasing-power parity (PPP) and the law of one price do not hold. An explanation for this evidence is that exporters can discriminate across markets and prices in local currency, i.e., they adopt a strategy of pricing to market (PTM).[2] Although the pricing strategy is a microeconomic decision, it has substantial macroeconomic implications. We examine how the pricing strategy affects the link between trade and the exchange rate regime. We will also investigate the optimality of the two pricing strategies (PCP and PTM) within the context of the model.

We consider the impact of macroeconomic risks on uncertainty about labour costs and demand that firms face, and how this is affected by the choice of exchange rate system. A partial-equilibrium approach, whereby the impact of exchange rate risk is considered in isolation, is useful only if the nominal exchange rate is uncorrelated with macroeconomic shocks, such as monetary, fiscal, and productivity shocks. Although exchange rates are highly volatile and seemingly unrelated to fundamental variables in the very short run, empirical evidence shows significant correlations between exchange rates and fundamentals in the medium run. Thus, we take the view that fundamental macroeconomic shocks affect demand and labour costs that firms face both through their impact on the exchange rate and through other channels. Therefore, instead of investigating the impact of the exchange rate per se, we study the impact of the exchange rate regime on the certainty equivalent of firm profits. The exchange rate regime matters to the extent that it affects the impact of macroeconomic shocks (monetary, fiscal, and productivity) on demand and costs faced by firms.

Trade will be lower under a flexible exchange rate regime only if switching to such a regime reduces the certainty equivalent of profits when exporting to foreign markets relative to selling in the home market. This is not necessarily the case, and the opposite may be true, e.g., selling in the foreign market can provide more risk diversification than selling in the home market.

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[2] In theory, exporters could price to market in their own currency. We do not consider this case here and assume that pricing to market is always done in local currency.

In this paper, we rely on developments in the New Open Economy Macroeconomics literature, characterized by general-equilibrium models with optimizing firms and consumers, combined with price rigidities.[3] More specifically, we present a model based on Bacchetta and van Wincoop (2000). In this framework, exporting firms need to set prices before macroeconomic risks are resolved. If firms find it very risky to sell in foreign markets, they will include a risk premium and charge a higher price that will discourage foreign consumers and thus reduce trade. On the other hand, if selling in foreign markets under a flexible exchange rate provides risk diversification, exporters will set a lower price so that trade is larger.[4]

While the Bacchetta-van Wincoop (2000) framework makes several strongly simplified assumptions, it provides a tractable framework in which quite general results can be derived. In particular, we can draw the following conclusions:

- The pricing strategy (PCP versus PTM) matters for the sensitivity of trade to the exchange rate regime.
- Trade is more likely to be affected under PTM. The impact of the exchange regime, however, is ambiguous because of general-equilibrium mechanisms.
- The existence of asset markets—such as forward markets or even complete markets—does not eliminate the sensitivity of trade to the exchange rate under PTM, although it may reduce it.
- In the absence of international asset trade, all firms choose the PTM pricing strategy.
- As international financial markets become more integrated, more firms adopt the PCP pricing strategy.

The rest of the paper is organized as follows. In the next section, we present the basic intuition behind the link between pricing and trade flows, as well as the pricing decision under PTM. In section 2, we briefly describe how general-equilibrium considerations affect the relationship between trade and the exchange rate regime. In section 3, we determine the optimal pricing strategy, i.e., under what conditions PTM or PCP are equilibria when firms can choose their strategy. The final section offers concluding remarks.

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[3] This growing literature started with Obstfeld and Rogoff (1995), who assume PCP and no uncertainty. Betts and Devereux (1996, 2000) extend it to PTM, while Obstfeld and Rogoff (1998) and Bacchetta and van Wincoop (2000) introduce uncertainty under PCP and PTM, respectively. This literature typically does not look at trade flows.

[4] We abstract from transportation costs. While they affect the level of trade, they do not have a significant impact on the sensitivity of trade to the exchange rate regime in a symmetric model like ours. See Sercu and Uppal (2000) for a general-equilibrium model where these costs matter.

1 Preliminary Concepts

Before describing the full structure of the general-equilibrium model, we present two basic ingredients of the analysis at a more intuitive level. We first look at the link between the pricing strategy and trade and then examine the price-setting criteria for firms.

1.1 Trade flows and the role of prices

We take an aggregate perspective on trade. Assume that there are only two countries (home and foreign) and that domestic goods are different from foreign goods. A standard measure of total trade is the sum of exports and imports divided by GDP. For convenience, in this section we consider only imports and assume that the nominal value of imports, *IM*, is given by:

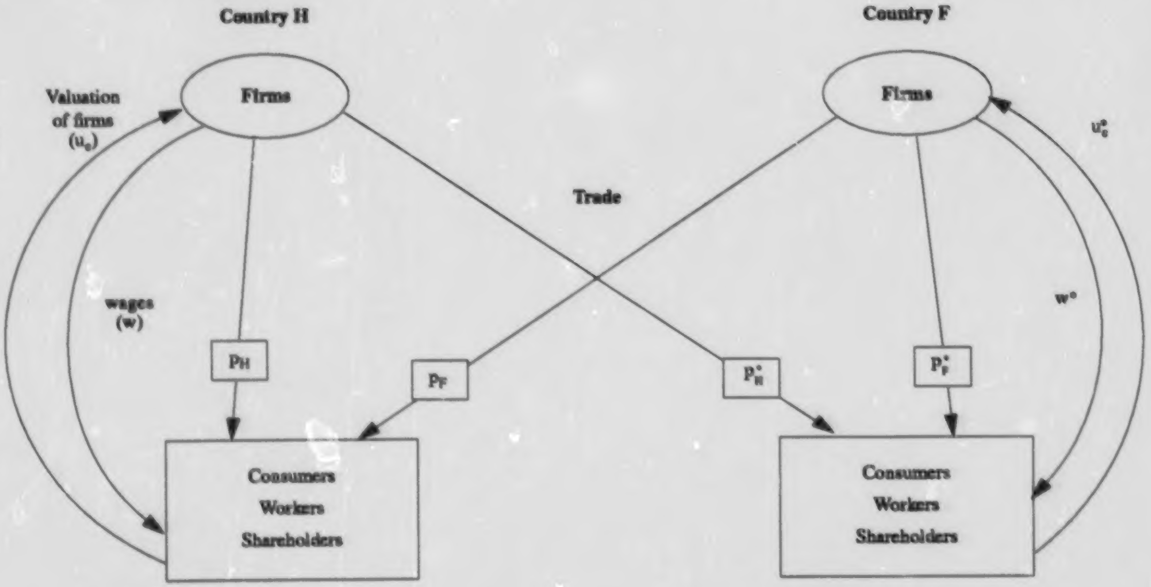
$$IM = p_F \cdot \Phi\left(\frac{p_F}{p_H}\right) \cdot \frac{Y}{P}, \tag{1}$$

where $p_F(p_H)$ is the price of imported (domestic) goods in the home country, and P is the home consumer price index. Figure 1 illustrates our notation for the pricing of goods. Since consumers purchase both domestic and foreign goods, P is a function of both goods prices. Thus, we can write $P(p_F, p_H)$, which is homogeneous of degree one in both prices. Moreover, Φ is a function that depends negatively on the relative price between imported and domestic goods, and Y is nominal GDP, which is assumed equal in equilibrium to nominal income. Trade can thus be measured by:

$$\frac{IM}{Y} = \frac{p_F \cdot \Phi\left(\frac{p_F}{p_H}\right)}{P(p_F, p_H)} \equiv \Psi(p_F, p_H). \tag{2}$$

The impact of exchange rate fluctuations depends on the pricing strategy and more generally on the degree of pass-through of the exchange rate to prices. Two extreme cases can be considered. First, assume that foreign exporters set the price, p_F, in the domestic currency of the importing country and that they can price discriminate across national borders, i.e., that we have PTM in local currency for all goods. In that case, domestic importers are not directly affected by exchange rate movements. The only way exchange rate volatility can affect trade is through the pricing of goods, i.e., the differences

Figure 1
Notation for the pricing of goods


Country H
Country F
Firms
Firms
Valuation of firms (u_c)
wages (w)
Trade
p_H
p_F
p_H^*
p_F^*
w^*
u_c^*
Consumers
Workers
Shareholders
Consumers
Workers
Shareholders

Under PTM: H firms set p_H, p_H^*

F firms set p_F, p_F^*

Under PCP: H firms set p_H. Then, $p_H^* = \frac{p_H}{S}$

F firms set p_F^*. Then, $p_F = S \cdot p_F^*$

In symmetric equilibrium, $p_H = p_F^*$

$p_F = p_H^*$

In symmetric equilibrium, $p_H = p_F^*$

between p_H and p_F. The higher the price charged in the foreign market relative to the home market (higher p_F / p_H), the lower the level of trade.[5]

The second extreme case occurs when all imports are priced in the exporters' currency and when exporters cannot discriminate between the domestic and the foreign market. This is the PCP case, where $p_F = S \cdot p_F^*$, with S being the nominal exchange rate (domestic per foreign currency) and p_F^* the pre-set price in the foreign market in foreign currency (which implies that, in this case, p_F fluctuates with S). Trade can be written as:

$$\frac{IM}{Y} = \frac{Sp_F^* \cdot \Phi\left(\frac{Sp_F^*}{p_H}\right)}{P(Sp_F^*, p_H)} \equiv \Psi(Sp_F^*, p_H). \tag{3}$$

In this case, we first see that trade fluctuates with the exchange rate; therefore, we must consider a measure of average or expected trade. Second, when countries are fully symmetric so that the prices of goods in domestic markets (home and foreign) are equal, i.e., $p_H = p_F^*$, the trade level depends only on the exchange rate. The level at which firms set prices is irrelevant. In a symmetric set-up, where S and $1/S$ have the same distribution, it is easily verified that the expected level of trade is independent of exchange rate volatility. The intuition is the following: a currency appreciation makes foreign goods cheaper, while a depreciation makes domestic goods cheaper. If both goods matter in a similar way to consumers, the effect will be symmetric, and an increase in the variance of the nominal exchange rate will not affect expected trade. This contrasts with the PTM case, where the level of trade can differ across exchange rate systems, depending on the effect of the exchange rate regime on p_F / p_H. The pricing strategy, therefore, affects the sensitivity of trade to the exchange rate system. In most of the paper, we will focus on the PTM case, since the effect of the exchange rate system on trade is non-trivial and depends on the level at which firms pre-set prices in the home and foreign markets.

An important dimension to consider is the presence of asset markets and the extent to which exporters and importers can hedge the exchange rate risk. It is obvious that if the exchange rate is the only source of risk and a forward market exists, agents in symmetric countries can fully hedge their exposure. In other situations, however, it may not be desirable or feasible to fully hedge exchange rate risk. In section 2, we examine the behaviour of producers and consumers in a general-equilibrium framework when no international asset market is available, and we go on to discuss the impact of international asset trade. Before we consider the full model, however, we describe in general terms what determines the degree of pricing discrimination of exporters under PTM.

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[5] For the price ratio, p_F/p_H, to have the expected negative result on imports, the real demand for imports must be sufficiently price-elastic, in a way similar to the Marshall-Lerner condition.

1.2 Optimal price setting

A critical channel for the impact of the exchange rate regime is the behaviour of firms—in particular, their optimal price setting. To gain intuition, we examine optimum price setting by a single firm that prices in the currency of its customers. We also relate our analysis to previous literature.

Consider a firm that sets prices in advance and is thus able to discriminate between the domestic, p_H, and the foreign price, p_H^*, in foreign currency. Markets are segmented; consumers cannot arbitrage price differentials. The foreign price expressed in domestic currency is Sp_H^*. The firm faces real demands $c(p_H / p_F, x)$ and $c^*(p_H^* / p_F^*, x^*)$ at home and abroad, where x and x^* represent aggregate factors affecting consumption demand. For convenience, assume that the demand functions have the same constant price elasticity, μ, and that $\mu > 1$. Finally, the firm has a linear production function, using $1/a$ quantity of labour per unit of output, independently of whether it is sold at home or abroad. It pays a nominal wage rate, w. Profits are simply:

$$\Pi = p_H c + Sp_H^* c^* - \frac{w}{a}(c + c^*). \tag{4}$$

Without uncertainty, the optimal price rule with a constant markup is well-known:

$$p_H = \frac{\mu}{\mu - 1}\frac{w}{a}. \tag{5}$$

If S is normalized to 1, it is obvious that $p_H^* = p_H$.

Giovannini (1988) introduces exchange rate uncertainty in this framework and assumes that the firm maximizes expected profits. The exchange rate is the only element of uncertainty facing the firm. In this case, the optimal domestic price is still given by (5), and the foreign price is:

$$p_H^* = \frac{\mu}{\mu - 1}\frac{w}{a}\frac{1}{E(S)}. \tag{6}$$

Exchange rate uncertainty has no impact on prices. Only its expected value matters. There is no ex ante price discrimination: $p_H = E(Sp^*_H)$. A crucial assumption for this result is risk neutrality, since firms care only about expected profits.

If firms are risk-averse, exchange rate uncertainty matters and would lead to a price that is higher in the foreign market, as first shown by Baron (1976). This reduces the level of trade.[6] However, many authors have shown that trade remains unaffected by exchange rate risk when firms have access to a forward market and when the forward discount is zero.[7] In that case, equation (6) still holds.

An important hypothesis underlying all of these papers is that the exchange rate is the only source of uncertainty.[8] However, firms typically face other sources of risk that are potentially correlated with exchange rate fluctuations. If we take the view that exchange rate changes are related to fundamentals, then the same variables that drive fluctuations in the exchange rate are also responsible for uncertainty about the wage rate, *w*, the aggregate demand factors, *x* and x^*, and the technology parameter, *a*. Thus, to understand the implications of different exchange rate regimes for price setting and trade flows, we need to compare the overall macroeconomic risks faced by firms under different monetary systems.

In a general-equilibrium setting, the firm maximizes the market value of profits, $E(q\Pi/P)$, where *q* represents the pricing kernel, which is the value that firms' owners attach to marginal revenue in different states of the world.[9] The pricing kernel is proportional to the marginal utility of consumption of the firm's owners, which we denote as u_c. This implies that the firm will be risk-averse when setting prices. When all macroeconomic variables are stochastic, optimal prices are:

$$p_H = \frac{\mu}{\mu - 1}\frac{E(u_c cw/a)}{E(u_c c)}, \qquad (7)$$

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[6] Hooper and Kohlhagen (1978) consider a somewhat different set-up, with both importers and exporters bearing part of the exchange rate risk. When exporters bear most of the risk, exchange rate uncertainty raises the export price and reduces trade. When importers bear most of the risk, exchange rate uncertainty reduces import demand (and therefore trade) and lowers the import price. In general, the price effect is ambiguous, but the trade effect is unambiguously negative.

[7] See Ethier (1973), Baron (1976), Viaene and de Vries (1992), and Feenstra and Kendall (1991).

[8] Adam-Müller (1997) includes both revenue and exchange rate uncertainty.

[9] The pricing kernel corresponds to the price of state-contingent claims if they are traded (which is not required for the pricing kernel to exist).

$$p_H^* = \frac{\mu}{\mu - 1}\frac{E(u_c c^* w/a)}{E(u_c S c^*)}. \tag{8}$$

Prices are still equal to a standard markup over unit cost.[10] The latter is now written as the certainty equivalent of total labour cost, divided by the certainty equivalent of sales. Equations (7) and (8) show that ex ante price discrimination can go in either direction, depending on the nature of the uncertainty. In the following sections, we develop a full model that determines the behaviour of the variables in equations (7) and (8).

Introducing a forward market does not change the optimum price equations (7) and (8). When firms take a hedge position of quantity b, we have to add the net profit, $b(F - S)$, to equation (4), where F is the forward rate. This additive term does not affect pricing rules, but it does affect the stochastic properties of c, c^*, S, and w (thus, the equilibrium prices do change). The case is the same when adding other internationally traded securities. This again shows that a general-equilibrium approach is unavoidable.

2 A General-Equilibrium Model

In this section, we describe—without presenting the technical details—a general-equilibrium model based on Bacchetta and van Wincoop (2000), when no asset markets are available. We outline the main insights that can be drawn from such a context. The main ingredients of the model are:

- There are two countries. The economic structure and the distribution of shocks are fully symmetric, while shock realizations usually differ across countries. Both productivity and monetary shocks occur.
- There is monopolistic competition, à la Dixit-Stiglitz. Consumers in each country value both domestically and foreign-produced goods. Thus, there is two-way trade.
- It is a monetary model, with money introduced through a cash-in-advance constraint. The equilibrium nominal exchange rate, S, depends on the ratio of money supplies, M and M^*, which have a jointly symmetric distribution. When money supplies are perfectly correlated, the exchange rate is fixed.
- Individuals consume and supply labour. They maximize expected utility, $EU(c, l)$, where c is total consumption, and l is leisure.

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[10] These equations are similar to those found in dynamic general-equilibrium models with PTM; see Betts and Devereux (2000); Chari, Kehoe, and McGrattan (2000); and Kollmann (1997).

- Producers set prices before knowing the realization shocks. The amount sold is determined by demand. Each good is produced with one unit of labour. The wage rate is flexible, so that the labour market is always in equilibrium.
- Producers have two potential pricing strategies: PCP or PTM. It is only with this second strategy that exchange rate risk can have a direct effect on trade.

Figure 1 shows the basic structure of the general-equilibrium model, abstracting from the monetary sector. Domestic firms are held exclusively by domestic consumers and hire exclusively domestic workers. The only international interaction is the sale of goods in foreign markets.

Given the monopolistic competition assumption, we show that the various demands relevant for the home country are (for a single good, *i*):

$$\text{domestic demand} \quad c_H(i) = \frac{1}{2}\left(\frac{p_H(i)}{P}\right)^{-\mu}\frac{M}{P},$$

$$\text{exports} \quad c_H^*(i) = \frac{1}{2}\left(\frac{p_H^*(i)}{P^*}\right)^{-\mu}\frac{M^*}{P^*},$$

$$\text{imports} \quad c_F(i) = \frac{1}{2}\left(\frac{p_F(i)}{P}\right)^{-\mu}\frac{M}{P}, \tag{9}$$

where μ is the elasticity of substitution between goods. When we define trade as the sum of exports plus imports, divided by GDP, it can be shown that:

$$Trade = \frac{\text{exports} + \text{imports}}{GDP} = \frac{Sp_H^*c_H^* + p_Fc_F}{Y} = \frac{2}{1+(p_H/p_F)^{1-\mu}}, \tag{10}$$

where we use the fact that, in equilibrium, quantities are the same for all firms.[11] As illustrated in section 1, the measure of trade can be fully determined by relative prices. Equation (10) is even simpler than equation (2), given the model's assumptions, in particular for symmetry. In the PTM case, firms set directly p_H and p_F, so that one needs to look at the optimal pricing decision. When $p_H = p_F$, our trade measure is equal to one (given symmetry, the same quantity of foreign and domestic goods is consumed).

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[11] Trade under PCP is analyzed by Bacchetta and van Wincoop (1998).

In the PCP case, we have $p_F = S \cdot p_F^*$ and by symmetry, $p_F^* = p_H$. Thus, for PCP, equation (10) can be written as:

$$Trade = \frac{2}{1 + S^{1-\mu}}, \tag{11}$$

which is simpler than equation (3). It is easy to show that expected trade is not affected by volatility when the exchange rate depends on the ratio of M and M^*, which have a jointly symmetric distribution.

Let us now examine the pricing-discrimination decision under PTM. In this case, Bacchetta and van Wincoop (2000) show that the nominal exchange rate is simply given by $S = M/M^*$. Since prices are pre-set in local currency, PPP does usually not hold ex post; i.e., $P \neq SP^*$.

As explained in section 1.2, domestic firm i sets prices $p_H(i)$ and $p_H^*(i)$ to maximize the market value of profits, $E(u_c\Pi(i))$; quantities in each market are given by equation (9). In the benchmark model considered by Bacchetta and van Wincoop (2000), the certainty equivalent of sales is the same when selling in the home market as when selling in the foreign market. More precisely, domestic sales are proportional to the domestic money supply, M, while the value of foreign sales is proportional to SM^*. Since $M = SM^*$, these are equal. One might have expected that the exporter faces a loss in the foreign market when the foreign currency depreciates (S drops). But this is offset by higher demand from abroad if the foreign currency depreciation is the result of a foreign monetary expansion (M^* rises). If the depreciation is the result of a domestic monetary contraction, revenue from sales drops the same in the home market as it does in the foreign market; therefore, in a relative sense, there is again no loss from selling in the foreign market.

Consequently, it is only the difference in the certainty equivalent of costs that matters. The price ratio is then given by:

$$\frac{p_H}{p_F} = \frac{Eu_c wM/a}{Eu_c wM^*/a}, \tag{12}$$

using the fact that $p_H^* = p_F$ in the symmetric equilibrium. With a fixed exchange rate, $M = M^*$, and the price ratio is equal to one (hence, the trade measure is equal to one). When the exchange rate is flexible, we show that the price ratio can be either larger or smaller than one so that trade can be either larger or smaller.

Trade will be lower in a flexible exchange rate regime when selling in the foreign market brings less risk diversification than does selling in the domestic market. This is the case, for example, when:

- Money supply is positively correlated with productivity shocks, *a* (e.g., to stabilize employment). The certainty equivalent of labour costs is then lower in the domestic market, since M/a is less variable than M^*/a.
- Consumption and leisure are substitutes in the utility of consumers. The wage rate is more correlated with domestic demand shocks than with foreign demand shocks, which makes the total wage bill more volatile in the home market and by itself makes the foreign market more attractive, leading to higher trade under a float. On the other hand, under domestic demand shocks the wage bill is high when firms can afford to pay it (more formally, u_c is low). When selling in the foreign market, it is possible that the wage bill is high when firms' revenues are low. This occurs when there is a domestic monetary contraction combined with a foreign monetary expansion. This leads to lower trade under a float. When consumption and leisure are substitutes, the wage rate is less procyclical, weakening the first channel and leading to lower trade under a float.

Bacchetta and van Wincoop (2000) also present conditions under which trade is unaffected by the exchange rate regime. This is the case when utility is separable between consumption and leisure, and monetary and productivity shocks are independent. In that case, the certainty equivalent of costs is the same whether producers sell at home or abroad.

Finally, Bacchetta and van Wincoop (2000) show that the direction in which the exchange rate system affects trade remains the same when we introduce international asset trade. Although international asset trade, even the extreme of complete Arrow-Debreu markets, can reduce the magnitude by which the exchange rate regime affects trade, it cannot eliminate the impact of the exchange rate regime on trade. Intuitively, this is the case because international financial markets cannot eliminate the difference between foreign demand and domestic demand as a function of the underlying shocks. Under complete financial markets, for example, the ratio of marginal utilities from domestic and foreign consumption is equal to the real exchange rate, which varies, one for one, with the nominal exchange rate.

3 But What Is the Optimal Pricing Strategy?

The pricing strategy adopted by firms has important macroeconomic implications. We have already seen that the impact of exchange rate volatility on trade depends on the two pricing strategies considered, PCP and PTM. The model also implies more exchange rate volatility under PTM pricing than under PCP pricing.[12] With PTM pricing, the exchange rate is $S = M/M^*$, while in the PCP case, we have:

$$S = (M/M^*)^{\frac{1}{n}}.$$

Finally, Devereux and Engel (2000) show that the pricing strategy (PCP versus PTM) plays a key role in determining the optimality of different exchange rate systems.

Now, which of these two pricing strategies is more empirically relevant? The shortcoming of PCP is that it implies a constant real exchange rate. It has been well documented that real exchange rates are very volatile and highly correlated with nominal exchange rates. For identical traded goods, the law of one price is grossly violated, and relative prices are closely correlated with the nominal exchange rate (see Engel 1993). This fits very well with the implications of PTM pricing. The exchange rate pass-through literature is insightful, as well. Under PCP, there is full exchange rate pass-through to import prices, while under PTM, there is no pass-through. The empirical evidence, reviewed in Goldberg and Knetter (1997), suggests that pass-through from exchange rates to prices, while varying across countries and industries, is, on average, no more than 50 per cent. The evidence in Engel (1999) suggests that at the level of consumer prices, there is almost no pass-through at all. At the consumer level, relative non-tradable prices across countries behave very much the same as do relative tradable prices.

Although it seems that the PTM assumption is more appropriate, an important question is whether this pricing strategy is consistent with the underlying microeconomic model used. In the New Open Economy Macroeconomics literature, this question is never asked, and the pricing strategy is assumed, a priori. The PCP strategy can be justified if price differences between foreign and domestic goods can be arbitraged at no cost. But arbitrage is often very costly, and even impossible when firms have exclusive product distribution rights in different countries. The pricing decision, therefore, is one that needs to be made by the firm. The question is whether exporters prefer PTM or PCP. We need to determine, within the context of the model, whether either of these pricing strategies is an equilibrium. For example, if all exporters apply PTM, is it optimal for a marginal firm to do the same? Mixed strategies, whereby some firms choose PTM while others choose PCP, may also be an equilibrium. It is important to address these questions both for internal consistency reasons in the context of the models used and for understanding what determines the optimal pricing strategy under different conditions. Our current research (Bacchetta and van Wincoop 2001) examines these issues, and we report on some of the results.

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[12] Betts and Devereux (1996) make the same point.

Consider an individual firm, *i*, in the environment described in section 2, where all other firms choose PTM. Firm *i* will compare the market value of its profits under both PTM and PCP strategies.[13] If PTM gives higher profits, there is no incentive to deviate from that equilibrium, thus PTM is a pricing strategy that is consistent with firms' optimal behaviour. Is there an incentive for an individual firm to deviate from PTM? Let us focus only on exports and remember that the certainty equivalent of profits is equal to the certainty equivalent of sales minus costs. On the cost side, firms prefer PTM, since it results in fewer variable quantities and therefore lower labour costs. The reason is mainly that foreign consumer demand under PTM is not directly affected by the nominal exchange rate. Therefore, there might be a deviation from PTM only if the certainty equivalent of sales can be higher under PCP. Under PTM, the certainty equivalent of firm *i*'s exports $X(i)$ is:

$$Eu_c X(i) = Eu_c S p_H^*(i) c^*(i) = \frac{1}{2}\left(\frac{p_H^*(i)}{P^*}\right)^{1-\mu} Eu_c S M^*, \tag{13}$$

while under PCP they are:

$$Eu_c \tilde{X}(i) = Eu_c \tilde{p}_H(i) \tilde{c}^*(i) = \frac{1}{2}\left(\frac{\tilde{p}_H(i)}{P^*}\right)^{1-\mu} Eu_c S^{\mu} M^*, \tag{14}$$

where ~ denotes variables under PCP and where we use the fact that under PCP there is a single price for home producers, $\tilde{p}_H = \tilde{p}_H^*$. Under PCP, export sales are more sensitive to the exchange rate, since $\tilde{c}^*(i)$ depends directly on S, and the price elasticity, μ, is larger than one. The higher variability of sales under PCP can, however, be compensated by the fact that the marginal valuation factor, u_c, may fluctuate inversely to the nominal exchange rate. Intuitively, when M drops and the marginal utility from domestic consumption is high, the revenue from exports is high under PCP, because the currency depreciation increases foreign demand—which makes the PCP strategy more attractive. Thus, there are cases where a firm will deviate from the PTM strategy, because PCP provides a better risk diversification. In general, however, it is not clear when firms would deviate from

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[13] In general, other pricing strategies are feasible, such as PTM in producers' currency, but we do not address these strategies here.

PTM and PCP pricing. This depends, in particular, on μ and on the concavity of the utility function with respect to consumption.

Similar reasoning can be conducted when all the other firms use PCP. In this case, it is also possible to show that the optimal pricing behaviour is ambiguous and depends on the parameters. An interesting question is whether there are circumstances (i.e., parameter values) where neither PCP nor PTM is an equilibrium. In this case, a solution to the optimal pricing strategy is to have a proportion of firms applying PTM, while others apply PCP. Whether such cases exist cannot be determined analytically, and numerical simulations must be used.

Another important issue is the role of asset markets. Since the optimal pricing strategy is influenced by risk-diversification considerations, different asset-market structures may influence the pricing strategy. Here again, the issue is complex, and no analytical results are yet available. Consequently, we will need to use simulations.

To obtain more specific results, we focus on a constant elasticity of substitution (CES) utility function:

$$U(c, l) = V(c, l)^{1-\gamma}/(1-\gamma), \tag{15}$$

where $V(c, l)$ is a CES index with ε the elasticity of substitution between consumption and leisure. Consumption and leisure are complements, separable, or substitutes, depending on whether $\varepsilon\gamma$ is respectively smaller than, equal to, or larger than, 1. In the separable case, it can be shown that the certainty equivalent of export sales is higher under PCP when $\mu > \gamma$. Since the certainty equivalent of labour costs is lower under PTM, we require situations where μ is clearly higher than γ to have PCP preferred by the marginal firm. If the marginal firm does prefer PCP, it only tells us that PTM adopted by all firms is not an equilibrium. It does not tell us that PCP is an equilibrium.

Table 1 presents simulation results under different values of γ and in the separable case $(\varepsilon\gamma = 1)$.[14] It snows that, depending on parameter, either PTM or PCP is preferred. However, for most plausible values of γ and μ, PTM is preferred by the marginal firm and is, therefore, an equilibrium. Most evidence shows that the rate of relative risk aversion, γ, is larger than 2

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[14] We assume that M and M^* can take on 11 equidistant values, with mean 0.5, standard deviation 0.075, and correlation 0.5. A final assumption is that the weight of the CES index is set such that $l = 0.5$ in the deterministic equilibrium, assuming that time (other than sleep and household chores) is divided equally between work and leisure.

Table 1
Optimal pricing strategy when other firms choose PTM
(Separable preferences and no international asset trade)

	γ			
μ	0.9	1.1	2	5
2	PCP	PTM	PTM	PTM
5	PCP	PCP	PTM	PTM
10	PCP	PCP	PTM	PTM
50	PCP	PCP	PCP	PTM

(e.g., Friend and Blume 1975). Hummels (1999) obtains estimates for μ in the range of 5 to 10.

Simulations can also be conducted when all other firms apply the PCP strategy. Our numerical results show that the marginal firm prefers PTM under all the parameter combinations of Table 1. Thus, PCP is not an equilibrium in this context. This also implies that there are parameter combinations, e.g., when γ is low, where neither PTM nor PCP is an equilibrium. In these cases, there will be "mixed" equilibria, where a proportion of firms apply PTM, while the others apply PCP.[15]

In all of these experiments, it is assumed that firms have no access to asset markets and thus cannot hedge. How does the availability of assets influence the optimal pricing decision?[16] We have run the simulations with the parameters of Table 1 under the assumption that all firms have access to complete financial markets.

We find that, for all parameter combinations, a marginal firm prefers PCP when other firms price according to PTM, while the marginal firm prefers PTM when all other firms price according to PCP. This means that neither PTM nor PCP is an equilibrium. There will be a mixed-strategy equilibrium, whereby a fraction of firms price according to PTM, while others choose PCP.[17]

To summarize, in the absence of international asset trade, PTM is an equilibrium for most plausible parameter values, while, under complete asset markets, there will be a mixed-strategy equilibrium. Overall, we may therefore conclude that the model's predictions are roughly consistent with empirical evidence. Since there is limited risk-sharing (e.g., see Athanasoulis and van Wincoop 2000), we are far from the complete market situation. The model would then predict that PTM is an equilibrium strategy, which is in keeping with empirical observation. As international financial markets become more integrated, the model would predict that PCP becomes a more attractive pricing strategy.

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[15] There could, in fact, be mixed strategies by individual firms or a "mix" of pure strategy. The two are equivalent, since the number of firms is infinite.

[16] In a partial-equilibrium framework, Friberg (1998) shows that PTM is preferred when a forward market is available.

[17] For implausible parameters that are not in Table 1, PTM can be an equilibrium. In particular, when $\gamma\mu < 1$, PTM is an equilibrium under complete asset markets.

Conclusion

This paper has examined the relationship between nominal exchange rate fluctuations and trade flows. It might be presumed that more exchange rate volatility increases the trade flow risk, thus decreasing trade flows. However, this presumption is too simplistic. First, we argue that we cannot analyze exchange rate volatility in isolation, but we do need to specify the exchange rate regime. The question, therefore, becomes whether trade is lower under a floating exchange rate regime. Here, we show that the answer is ambiguous and that it depends on many factors, and in particular on the pricing strategy. Trade is only affected by the exchange rate regime when firms apply PTM. We argue that PTM is more empirically relevant than PCP and for reasonable parameters is indeed an optimal pricing strategy for firms when markets are incomplete. While we have provided examples where trade is lower under a float with PTM, in general it can go either way, depending on preferences and on the way monetary policy is conducted under a float.

Some readers might wonder whether this is a sterile theoretical exercise. True, part of our investigation is still at an early stage and more work needs to be done to fully apply it to the real world and to resolve several ambiguities. In particular, it would be interesting to conduct empirical studies based on the present framework to help determine what aspects of the model should be amended or extended. Overall, however, we strongly believe that the general-equilibrium approach presented here is more fruitful than partial-equilibrium or ad hoc models in understanding the impact of the exchange rate regime.

One of the advantages of the approach is that welfare conclusions can be drawn. This is done in detail in Bacchetta and van Wincoop (2000), where we present conditions under which a fixed exchange rate is preferred to a flexible regime. One of the results is that there is no one-to-one relationship between trade and welfare; e.g., a fixed exchange rate regime may increase trade, but lower welfare. So even when the presumption that exchange rate volatility reduces trade is correct, it does not necessarily mean that welfare is lower under a float.

We have also shown that the asset-market structure plays an important role in the pricing strategy. The model suggests that as financial markets become more integrated, firms are more likely to switch to PCP, leading to lower real exchange rate fluctuations and a reduced impact of the exchange rate regime on trade. While financial markets affect the pricing strategy of firms, we could have a reverse causality. The currency denomination of goods trade could affect the currency denomination of asset trade, leading to a potentially interesting simultaneity problem that is beyond the scope of this present paper.

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Discussion

Kevin Clinton

Introduction

Bacchetta and van Wincoop have developed an elegant approach to the effects of exchange rate volatility on pricing and trade. This paper, in conjunction with their earlier contributions, provides several useful innovations. After their approach using a general-equilibrium framework, it will be difficult to excuse the use of partial-equilibrium analysis in future research. The introduction of multiple, simultaneous sources of uncertainty is also important. The authors are able to examine the incremental contribution of currency risk, not just in isolation, but in the context of overall risk in an uncertain environment. In doing so, they help to fill a gap noted by Agathe Côté in her 1994 survey. The model also incorporates monopolistic competition with market segmentation and price discrimination. And, the model allows firms two pricing options: pricing to market (PTM) and producer currency pricing (PCP), both of which are, in fact, widely used.

This framework is rich in implications. The authors are able to provide an explanation, in terms of risk aversion, of the circumstances under which firms might prefer one pricing arrangement over the other. Optimal price-setting behaviour can be derived under either option. If a non-traded service were introduced into the model, purchasing-power parity (PPP) will not hold under either—changes in the nominal exchange rate would cause changes in the same direction in the real exchange rate measured in terms of the average price of consumer goods. PTM has the much stronger property that the law of one price for a given good will not hold. As the authors note, there is vast empirical evidence of deviations from both PPP and the law of one price.

All this suggests that we have a good theoretical framework for exploring the effects of exchange rate volatility on trade. And the results that emerge are strong, indeed stronger than the authors let on.

Bacchetta and van Wincoop, like various earlier authors, stress the *ambiguity* of the theoretical effects of exchange rate volatility on trade. One could easily get the impression from their paper (the concluding section, for example), that there are no refutable hypotheses for trade volume under alternative regimes. However, let us review the findings:

- Trade is not affected at all by the exchange rate regime when firms apply the PCP strategy.
- As financial markets become more integrated, firms are likely to switch to the PCP strategy. (More generally, the greater the number of financial opportunities for hedging, the slighter the effect of exchange rate volatility on trade.)
- Trade volume might be affected under the PTM strategy, but the direction of the effect is not clear.
- In any case, welfare is not necessarily correlated with trade volume.

My reading is that the exchange rate regime has *negligible* theoretical implications for trade volume (and for welfare)—the effect of increased currency volatility on trade volume might be positive or negative, but there is no reason to think that the effect either way would be substantial. For empirical testing, the working hypothesis that emerges is that exchange rate volatility has no effect on trade.

Is there a bias in the model towards underestimating the effects of the exchange rate regime? If anything, the bias might be the opposite. For nominal variables to have an effect on real quantities, nominal frictions of one kind or another are required, and the model is likely to exaggerate the rigidities implied by PTM.[1]

Prices are assumed to be set for a period during which shocks may come from the monetary sector or from productivity. Unless I am mistaken, the length of this period would be the time needed by firms to ascertain the existence and nature of a shock to their wage costs. Yet during this period, the wage rate is flexible, and exports and imports are demand-determined. Therefore, it is assumed that the period of the financing and pricing decisions is *longer than* the implicit term of the wage contract and *the same as* the period over which the real exchange rate affects trade.

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[1] My argument would also apply to the cash-in-advance constraint.

This might not be realistic, by an order of magnitude. On the one hand, firms have a strong incentive to be up-to-date on vital information like the wages and productivity of their workforce—let's say their recognition lag is weeks, or months at the most. (If firms do fix the foreign currency prices of their exports for considerably longer than this—as empirical evidence indicates—a factor absent from the model is likely at work.) On the other hand, typical wage or salary contracts last at least a year. Likewise, conventional estimates of the mean lag of the import response to relative price changes typically exceed one year (e.g., the import equations in the Bank's QPM model). The period in the model thus seems to imply implausibly slow recognition of shocks or implausibly rapid responses of trade flows. The effects of PTM on trade flows are, therefore, more likely to be exaggerated than underestimated. This consideration reinforces my view that the implied working hypothesis from the theory is that exchange rate volatility has no effect on trade volume.

Choice of exchange rate regime is an extremely important matter for various reasons. But theory indicates that the effect of exchange rate volatility on trade is not one of them. And the empirical results—showing weak or nonexistent effects, at least if currency unions are left aside—seem to be in line with the theory.

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General Discussion

David Laidler began the discussion period by remarking that the coefficient on the real energy terms-of-trade variable in the Bank of Canada's exchange rate equation declines in absolute magnitude over the latter half of the sample period, in particular over the 1990s. He wondered whether the significance of this variable was due to the oil price shocks of the 1970s and whether further investigation had revealed anything of note. John Murray agreed with Laidler's observation, but noted that although the coefficient is statistically significant, its small size implies that it does not have a large impact on the estimated value of the exchange rate.

Charles Freedman spoke briefly on the role of the exchange rate in the policy formulation process. He noted that the correlation between the exchange rate fitted by a regression on commodity prices and the interest rate differential does not imply that monetary policy is aimed at the exchange rate but rather that the exchange rate and interest rate differential are both endogenous variables and reflect the state of aggregate demand in Canada. He went on to say that central banks should not react to exchange rate movements driven by real factors. Nonetheless, there may be portfolio shocks, which have occurred in the past, that might warrant a central bank response.

Gregor Smith said that there were periods in the mid-1970s, early 1980s, and early 1990s when commodity prices were coming down and the interest rate differential was going up, not down. He felt that, at a minimum, these periods make it difficult to convince the public that the commodity price trend is what drives the real exchange rate in all periods.

John Broadbent reported that the commodity terms of trade in the Reserve Bank of Australia's exchange rate equation appears with the predicted sign (higher commodity prices cause a real appreciation). He added that, in Australia, they wouldn't care whether chartists or fundamentalists were in the market, but whether the exchange rate was far from their estimate of the equilibrium level.

Carmen Reinhart noted that the prediction of Bacchetta's model under local currency pricing is consistent with the fact that there is no conclusive empirical evidence that nominal exchange rate volatility hurts trade for industrialized countries. In commenting on the Djoudad et al. paper, she felt that the policy prescription that there should be less foreign exchange market intervention by central banks does not follow from the empirical results, because the reaction of central banks to periods of turbulence may have caused the trading activity by fundamentals-based traders.

John Murray responded by noting that he and others had found little evidence that sterilized intervention by the Bank of Canada had any material effect on the exchange rate.

John Crow expressed doubt that the relatively high energy intensity of Canadian industry can adequately explain the counterintuitive negative sign of the energy price variable in the Canadian exchange rate equation in the Djoudad et al. paper. He asked whether the authors had empirically tested this explanation. John Murray responded that while they had not explicitly tested for it in the equation, it was recently determined that Canadians use 50 per cent more energy than Americans on a per capita basis. In addition, he noted that when energy prices rise sharply, this slows the U.S. economy and reduces Canadian exports.

John Helliwell also expressed doubts on the energy-intensity argument, but felt that sharp increases in energy prices for some inexplicable reason cause investors to purchase U.S. dollar assets in a flight to quality. Consequently, the Canadian dollar and other currencies depreciate.

Session 4:
Exchange Rate Uncertainty, Investment, and Productivity

Exchange Rate Variability and Investment in Canada

*Robert Lafrance and David Tessier**

Introduction

This paper examines the relationship between the real exchange rate and investment. The specific question that we address is the extent to which the flexible exchange rate regime might have been detrimental to investment in Canada. It has been suggested that flexible exchange rates can lead to excessive short-term exchange rate volatility and episodic bouts of currency misalignments, hampering the continental integration that was stimulated by the Canada-U.S. Free Trade Agreement (FTA) and NAFTA and limiting profitable trade opportunities.[1] For example, Courchene and Harris (1999) argue that while floating exchange rates are a smaller problem for commodity producers, since most resource exports are already priced in U.S. dollars and currency hedging is relatively straightforward, the lack of longer-run hedging facilities can make exchange rate movements problematic for the manufacturing sector. Their point is that free trade requires stable and predictable rates of international exchange and cost calculations to support the volumes of trade and the degree of specialization

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[1] The effect may not be large. Gaston and Trefler (1997) estimate that tariff cuts under the 1988 Canada-U.S. FTA explain only 9 to 14 per cent of lost manufacturing jobs during 1989–93, the bulk of which could be traced to the combined effects of corporate restructuring that predated the FTA, a severe recession, and the monetary policy stance during the period.

* We are grateful to Kevin Clinton and James Powell for their comments and suggestions. Tracy Chan provided us with excellent technical support.

associated with it. In their view, flexible exchange rates provide inherently volatile and unpredictable cost structures.

Similar concerns were expressed in the decades following the collapse of the Bretton Woods exchange rate arrangements, since nominal (and real) exchange rates movements—notably the wide swings in the U.S. dollar in the early 1980s—were considerably larger than the earlier advocates of floating had expected, and the higher short-run exchange rate volatility showed no sign of declining over time. Moreover, exchange rate volatility was markedly higher under the flexible regime, despite the fact that the volatility of macroeconomic variables had not increased, suggesting that a move towards more stable exchange rates would not result in greater macroeconomic instability. Added to the mix was the observation that most exchange rate movements were unexpected, as indicated by the fragility of exchange rate forecasting models and the inability of market indicators (such as interest rate differentials and forward rates) or market surveys to anticipate major changes.

However, the fact that exchange rate changes have been larger than expected, and not very predictable, does not necessarily imply that they have been harmful. The more pronounced exchange rate movements in the post-Bretton Woods era may have been required to absorb the economic shocks that characterized the period. Moreover, the fixed exchange rate regime would not have been able to accommodate these shocks without the imposition of controls on capital movements and restrictions on trade.

Three basic issues must be considered in the analysis of how the exchange rate can affect investment decisions. The first relates to the direction of influence. In a microeconomic context, at the level of the firm, we can speak of the exchange rate affecting the firm's decisions. However, in a macroeconomic context, the relationship is more likely to be bi-directional. Thus, we present some causality tests that suggest that while the real exchange rate does not appear to have a direct effect on investment (and there is no significant impact of investment on the exchange rate), it might have an indirect effect through its impact on corporate profits.

The second issue relates to the nature of exchange rate variability. In terms of its potential impact on investment, it can be broken down into two basic types: (i) short-run volatility and (ii) currency misalignments (or significant deviations from fundamentals). To the extent that short-run volatility is relatively bounded and represents "price-seeking" behaviour by the market (or simply incompressible noise in a flexible exchange rate regime), it is unlikely to significantly influence investment decisions that require a long-term perspective. However, short-run volatility could affect the timing of investment decisions in the presence of capital-market imperfections. Thus, we test for possible effects of short-run real exchange rate volatility on foreign direct investment (FDI) and domestic investment flows (total and for machinery and equipment (M&E)). For the three measures of investment that we consider, we find in all instances that short-run volatility does not have a noticeable short-run effect on investment flows.

Persistent real exchange rate disequilibria (i.e., misalignments) are more likely, however, to distort investment decisions, leading to both over- and under-investment. The basic problem with diagnosing misalignments, however, is that the existence, magnitude, and persistence of disequilibria are often in the eye of the beholder and can boil down to beliefs regarding the efficiency of markets. In other words, there is no consensus on how to measure real exchange rate disequilibria.[2] Despite our belief that currency markets are basically efficient and that movements in the Canadian dollar reflect economic fundamentals, we make a modest attempt to provide estimates of "misalignments," using an H-P filter and deviations from an estimated exchange rate equation. For the two cases that we consider, we find that misalignments have no significant short-run impact on investment.

The third issue is how to interpret our results to answer the initial question of whether Canada's flexible exchange rate regime has somehow been harmful to investment in Canada. First, we wish to make clear that our goal is not to determine whether investment has been misallocated (i.e., gone to the "wrong" sectors), since we focus only on aggregate investment, or whether the degree of foreign ownership has been affected, but simply to see whether exchange rate volatility or misalignments have reduced the level of investment. An examination of the impulse-response functions in the context of the vector-autoregression (VAR) specifications that we considered indicates that exchange rate shocks (in terms of levels or volatility) do not appear to have a significant impact on investment.

The outline of the rest of the paper is as follows. Section 1 provides a selective review of the literature on possible linkages between the exchange rate and FDI, reporting also on relevant empirical evidence. Section 2 does the same for domestic investment. Section 3 provides new evidence based on a VAR approach. Conclusions follow.

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[2] See Williamson (1994) for a discussion of the issues.

1 Foreign Direct Investment

1.1 Theories

While we focus on how exchange rate variability affects FDI, the influence could be in the other direction.[3] For instance, an exogenous inflow of capital could lead to a real exchange rate appreciation or depreciation, depending on whether the inflows are used to finance domestic spending or capital accumulation in the traded or non-traded goods sectors (Dornbusch 1973). Alternatively, an exchange rate stabilization policy might lead to a real appreciation of the currency and higher domestic interest rates, inducing greater capital inflows (Corbo 1985). An appreciation of the real exchange rate resulting in a large current account deficit might also induce foreign firms to invest in the local economy for fear of protectionist measures.

Direct investment in foreign countries will be chosen instead of exports, only to the extent that the location itself confers a substantial advantage to the firm (including lower production costs and host-country inducements).[4] Dunning (1988) integrates different perspectives in the literature, incorporating elements of the industrial organization approach, internalization,[5] and location theory. To motivate FDI, three conditions are required: (i) the firm must have some ownership advantages with respect to other firms;[6] (ii) it must be more profitable for the firm to use these advantages than to sell them or lease them to other independent firms; and (iii) it must be more beneficial for the firm to use these advantages in combination with some factor inputs located abroad, otherwise foreign markets would be served exclusively by exports.[7]

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[3] See Kosteletou and Liargovas (2000) for a fuller discussion.

[4] McClain (1983) and Lizondo (1990) provide insightful reviews of the literature.

[5] The internalization hypothesis explains the existence of FDI as a result of firms replacing market transactions by internal transactions, notably as a way of avoiding imperfections in the markets for intermediate inputs.

[6] The industrial-organization (I/O) approach argues that foreign firms possess advantages that are transferable abroad but not available to local competitors. In addition, the market for selling these advantages must be imperfect, otherwise the firm would not have an incentive to invest abroad. Market imperfections include product differentiation, marketing skills, proprietary technology, managerial skills, and discriminatory access to capital markets, economies of scale, and government-imposed market distortions.

[7] Itagaki (1981) provides a theory of the multinational firm under exchange rate uncertainty. His model takes into consideration taxation, transfer pricing, repatriation of profits, intermediate inputs, intrafirm trade, royalties, choice in currency denomination, and hedging. He shows that the effects of uncertainty on production and trade volumes depend on whether exposure to exchange rate risk is positive or negative and that volumes may increase under uncertainty. Thus, uncertainty may well increase world trade and investment. Also see Itagaki (1987).

Aizenman (1992, 1994) develops a model where risk-neutral producers can diversify internationally to increase the flexibility of production in response to shocks under conditions of free entry. He shows that a fixed exchange rate regime is more conducive to FDI relative to a flexible exchange rate regime for both real and nominal shocks. Fixed exchange rates are better at insulating real wages and production from monetary shocks and are associated with higher expected profits. The higher expected income, in turn, supports higher domestic and foreign (direct) investment. In the case of productivity shocks, flexible exchange rates lead to lower volatility in employment and lower expected profits, because the exchange rate moves to moderate the shock. In this model, flexible exchange rates limit the firms' incentive to shift production to the most productive economy by absorbing productivity shocks.

FDI can also be viewed as a type of international portfolio diversification at the corporate level (i.e., investment decisions are based on risk-return characteristics of alternative projects). However, for the diversification motive to have any explanatory power for FDI, the assumption of perfect capital markets must be dropped. The market-imperfections approach provides necessary but insufficient conditions for FDI. In the absence of other imperfections, neither exchange rate risk nor disequilibrium levels of exchange rates are necessary or sufficient for the occurrence of direct investment. They can, however, be "proximate causes" for direct investment. Various arguments have been proposed in this vein.

Aliber (1970) proposes an exchange risk theory. He argues that firms from countries whose currencies command a premium have an advantage in investing abroad.[8] However, it is not clear why hedging or a diversification advantage should accrue to only the strong currency firms, or why investors show persistent ignorance or short-sightedness. Another argument is that incomplete information, which makes external financing more expensive than internal financing, can lead to a situation where wealth effects resulting from exchange rate movements will influence FDI flows (Froot and Stein 1991). By lowering the relative wealth of domestic agents, a depreciation of the domestic currency can lead to foreign acquisition of domestic assets.

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8. Even though firms receive a stream of earnings in the discounted currency by investing abroad, Aliber postulated that the market capitalizes this host-country stream of earnings differently if it is earned by a source-country firm than by a host-country firm. This could occur because investors are ignorant of the fraction of a firm's income that derives from discounted currency areas, because the source-country firm can provide the investor with a diversified portfolio at a lower cost than he can on his own or because the source-country firm is more efficient at hedging risks. Studies of FDI in the United States, the United Kingdom, Germany, France, and Canada yielded results that were consistent with this hypothesis (Agarwal 1980).

1.2 Evidence

While most of the hypotheses explaining FDI flows have some empirical support, there is not sufficient support for any single hypothesis (Lizondo 1990). I/O theories have probably gained the widest acceptance. They seem to provide a better explanation for cross-country, intra-industry investment and for uneven concentration of FDI across countries than do alternative models.

Higher exchange rate volatility was found to be associated with higher direct investment *outflows* from the United States to Canada, France, Germany, and Japan (Cushman 1985), as well as *inflows* from these countries (Cushman 1988). However, Bailey and Tavlas (1991) were unable to find any adverse impact on exchange rate volatility or misalignment on real direct investment in the United States during the floating rate period.[9] Caves (1989) examines the sensitivity of U.S. FDI in flows to the exchange rate for 15 countries over the 1977–85 period.[10] His results indicate that stronger growth in the United States fosters more FDI from other countries. An appreciation of the dollar tends to discourage FDI, but FDI flows do not seem to respond to exchange rate expectations. *Ceteris paribus*, lower (higher) stock prices in the United States (abroad) favour inward FDI. He concludes that risk-aversion considerations may well promote rather than repel foreign investment.[11] In support of their theory, Froot and Stein (1991) find that U.S. dollar depreciations were associated with additional FDI inflows over the 1978–88 period. However, Stevens (1993, 1998) found their results to be fragile. When the sample is extended to 1991, the coefficient becomes insignificant.

Goldberg and Kolstad (1995) examine the effect of short-run exchange rate variability on U.S. bilateral FDI flows with Canada, Japan, and the United Kingdom over the 1978–91 period, by testing a model based on risk-aversion arguments. They find that exchange rate variability had a positive and statistically significant effect on four of the six bilateral FDI shares: real exchange rate variability increased the share of total U.S. investment capacity located in Canada and Japan and increased the share of Canadian and U.K. investment located in the United States. Moreover, the exchange rate *levels*, included as an additional variable, entered with the expected signs in all the regressions: exchange rate depreciations of the source country currency led to a reduction in investment flow shares to foreign markets. However, these effects are neither large nor statistically significant. Kosteletou and Liargovas (2000) examine the relationship between FDI flows and the real exchange rate in a simultaneous equation model for a large sample of industrial countries (but not for Canada), based on annual data over the 1960–97 period. They find that, for most countries, a real exchange rate appreciation induces greater FDI inflows.

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[9] In testing a hybrid model of direct investment incorporating portfolio balance and I/O characteristics for Japanese investment in 12 U.S. industries, Mann (1989) could not find evidence that the exchange rate was a significant determinant of these investment decisions.

[10] He argues that exchange rates have an impact on FDI inflows through two channels. First, they affect a firm's real costs and revenues. The net effect on FDI is ambiguous, however; it depends on the share of imported inputs and exported production. Second, exchange rates affect FDI inflows through expectations: a depreciation that is expected to be reversed will encourage FDI inflows so as to obtain a capital gain when the domestic currency appreciates.

[11] McClain (1983) finds evidence that a stronger currency (in real terms) leads to more FDI outflows into the United States for some countries (four out of eight). Moreover, in the late 1970s, low-priced U.S. stocks may have been associated with direct investment into the United States by Canadian, British, Japanese, and French investors. But the results, in his view, are hardly conclusive.

The ambiguity of the reported empirical findings is reminiscent of those in numerous studies on exchange rate uncertainty and trade flows. The effect of greater exchange rate volatility on trade is ambiguous in theory because it creates profit-making opportunities and increases the uncertainty of profits of export sales in foreign currency. The effect of volatility depends on the degree of risk aversion and risk exposure.[12] While the notion that exchange rate volatility is detrimental to trade is intuitively appealing since it increases business risks and disturbs planning, the effect is not obvious once firms are allowed to diversify across markets, use inputs from both home and abroad, adopt flexible invoicing arrangements, or have access to hedging instruments.

It is not surprising, therefore, that surveys of the empirical literature generally indicate either the absence of a link between measured exchange rate variability and the level of trade or, at best, mixed results.[13] Concerns have also been expressed by proponents of fixed exchange rates that sizable exchange rate misalignments can lead to trade hysteresis. However, the evidence does not generally support this hypothesis for the United States (Krugman 1990) or Canada (Amano, Beaulieu, and Schembri 1993).[14]

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[12] Even if a firm is risk-averse, it does not necessarily follow that an increase in risk leads to a reduction of the risky activity. For instance, highly risk-averse firms worry about the worst possible outcome. When risk increases, they may export more to avoid a drastic decline in their revenues. The probability of making large profits also increases when exchange rates are more variable. See Côté (1994) for a fuller discussion.

[13] See International Monetary Fund (1984) and Côté (1994). Klaassen (1999) argues that the reason it is difficult to get significant effects of exchange rate risk on trade flows is that the effects take time. He finds, based on U.S. bilateral trade flow data with its G-7 partners, that export decisions are most affected by the exchange rate one year later. The riskiness of the exchange rate at this horizon appears fairly constant over time. More recent work has challenged the conventional wisdom. For instance, Frankel (1997) and Rose (2000) estimate rather large trade-augmenting effects from greater exchange rate stability, notably by moving to a currency-union arrangement.

2 Domestic Investment

2.1 Theories

The effect of uncertainty on investment spending is ambiguous. Greater price uncertainty can lead competitive risk-neutral firms to increase investment (Hartman 1972; Abel 1983).[15, 16] In contrast, the literature on irreversible investment (Pindyck 1991) shows that increased uncertainty retards investment spending by risk-neutral firms if (i) the cost of reducing the capital stock exceeds the upward adjustment cost and (ii) firms operate in imperfect competition (Caballero 1991). Under these two conditions, an increase in price uncertainty causes the expected regret of having too much capital to rise relative to having too little. The firm responds by investing less.

The decision is not only *whether* to invest, but *when*. The Dixit-Pindyck model determines a zone of inactivity for the product price, within which a firm benefits by waiting (the option value of waiting), or by delaying investment decisions. Dixit calls this view of investment "a theory of optimal inertia" (Dixit 1992, 109). Firms that refuse to invest when the currently available rates of return are far in excess of the cost of capital may be waiting, based on an optimal calculation, to be more certain that these conditions are not transitory. In this model, investment proceeds if the price is above the upper thresholds of the range and is abandoned if it is below the lower bound. Thus, one has to consider how more pronounced misalignments or an increase in exchange rate volatility would affect the size of the zone of inactivity and the upper part of the price distribution (i.e., the frequency at which investment expenditures are made).

Building on this approach, Darby et al. (1998) show that more exchange rate variability uncertainty can actually increase investment. It can happen in industries where the scrapping price of any investment is low and the risk of being stuck with an unwanted investment is high. It can also occur when the increase in uncertainty is large or the initial environment is one of low uncertainty, and the opportunity cost of waiting, rather than investing, is high. Greater exchange rate stability would encourage investment in industries with relatively lower productivity, high scrapping value, and low-opportunity costs of waiting (e.g., service industries). However, greater exchange rate stability would tend to reduce investment in industries with low scrapping prices (e.g., public utilities) or high entry costs (e.g., high-tech and R&D) or in industries with high scrapping values combined with high-opportunity costs of waiting (e.g., financial services).

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[14] Giovannetti and Samiei (1995) used data on manufacturing exports for the United States, Germany, and Japan over the 1975–93 period and found strong evidence of hysteresis only in the case of Japanese exports.

[15] This result is due to Jensen's inequality. If the marginal revenue product of capital is convex in price, then a mean-preserving increase in price uncertainty raises the expected payoff to marginal units of capital and stimulates investment.

[16] Risk aversion (Craine 1989) and credit rationing (Greenwald, Stiglitz, and Weiss 1984) have also been advanced as possible reasons to explain why greater uncertainty could reduce investment.

The exchange rate could also affect investment by its effect on the cost of imported capital goods or, as some have suggested, by its effect on the competitive environment. Lafrance and Schembri (2000) discuss these issues in their analysis of how real exchange rate movements could have an impact on productivity growth in one country relative to another. The "exchange rate sheltering hypothesis" posits that a depreciating real exchange rate can be harmful to domestic productivity growth because it shelters domestic firms from foreign competition, thus reducing their incentive to make productivity-enhancing investments. However, this hypothesis is inconsistent with profit-maximizing behaviour and requires that capital markets be relatively inefficient.[17] Lafrance and Schembri also observe that in the 1990s the real exchange rate depreciation of the Canadian dollar, by increasing the cost of imported machinery and equipment and by lowering the cost of labour relative to capital, most likely contributed to lower productivity growth in Canada than in the United States. They note, however, that this real depreciation was driven by fundamental factors and would have occurred irrespective of the exchange rate regime in place.

2.2 Evidence

Baxter and Stockman (1989) use a post-war sample of 49 countries to compare the behaviour of output, consumption, trade flows, and real exchange rates under alternative regimes. Except for greater exchange rate variability under floating rates, they find little evidence of systematic differences in the behaviour of macroeconomic aggregates or international trade flows under alternative exchange rate systems.[18] Moreover, in Canada's case, there is no indication that the changes in the variability of the trade balance were due to shifts in the exchange rate regime. Rose (1994, 1995) and Flood and Rose (1995) look at the performance of key macroeconomic variables (but not investment) under different exchange rate regimes. They find that the volatility of other macroeconomic variables is not significantly affected by the exchange rate regime, which suggests that much of the volatility of nominal exchange rates must be due to nonfundamental factors and could be eliminated at little cost.

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[17] The hypothesis assumes that managers adopt a "satisfying" rather than profit-maximizing behaviour, that shareholders are inattentive to value of the firm, and that the capital and product markets are uncompetitive.

In contrast, Caporale and Pittis (1995) find that regimes matter. They examine the behaviour of some key macroeconomic variables under alternative exchange rate regimes (using monthly data over the 1960–91 period for 18 OECD countries), by looking at persistence, volatility, and the relative importance of symmetric (worldwide) versus asymmetric (country-specific) shocks as the driving forces of business cycles. Unemployment and real interest rates are more persistent under a floating exchange rate regime, whereas industrial production and real exchange rates are less persistent. Principal components analysis indicates that the *post*-Bretton Woods era is characterized by greater international correlation of business cycles and that cyclical movements have become less country-specific.

In a series of insightful papers, José Campa and Linda Goldberg analyze how the exchange rate could affect the investment and pricing behaviour of manufacturing firms in the United States and other major economies.[19] Their basic framework is a model of investment with adjustment costs that takes into account export sales and the use of imported inputs in production, both of which expose producers to exchange rate movements. Investment is a function of the marginal profitability of capital. Exchange rate changes can affect profitability by passing through into home and export market prices and imported input prices. The impact of exchange rate movements on profitability and investment decisions depends on the firm's international orientation and the competitive structure of the industry. *Ceteris paribus*, highly competitive industries are expected to exhibit larger responsiveness to exchange rates. The sensitivity of investment to the expected marginal profitability of capital declines for industries with high depreciation rates and adjustment costs and for those that put a low weight on future expected profits.

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[18] Note that an earlier IMF study on fixed-capital formation in the G-7 over the 1960–82 period concluded that "there is no real evidence that the rate of investment in the industrial world has been weaker during the period of floating exchange rates than it was earlier" (IMF 1984, 28).

[19] Campa and Goldberg (1997) document the external orientation of manufacturing industries for Canada, Japan, the United Kingdom, and the United States. They note that, unlike U.S. manufacturing industries where the direction of external orientation has swung back and forth, Canada's manufacturing industries have moved steadily towards greater positive net external orientation (p. 60). Between 1974 and 1993, overall manufacturing export and import shares actually doubled.

Campa and Goldberg (1995) report that the effect of the exchange rate on investment can change as patterns of external exposure shift over time. While U.S. manufacturing sectors were primarily export-exposed in the 1970s, they became predominantly import-exposed by the early 1980s. Consequently, exchange rate appreciations reduced investment in durable goods sectors in the 1970s but stimulated investment after 1983. While exchange rate volatility depressed investment, the effects were small. Campa and Goldberg (1999) extend these results and estimate their model for the two-digit manufacturing sectors of the United States, the United Kingdom, Canada, and Japan. They find that, across countries, exchange rates tend to have insignificant effects on investment rates in high markup sectors. However, investment responsiveness to exchange rates is fairly strong in low markup sectors. Surprisingly, there is no significant effect for either low or high markup industries for Canada.

3 Testing for Exchange Rate Effects on Investment

In this section, we examine whether real exchange rate movements might have had a significant impact on investment over the recent flexible exchange rate period.

While the exchange rate can be considered as exogenous to a firm's decisions in a microeconomic context, this assumption is debatable at a more aggregate level. As our interest lies in investigating macroeconomic relationships, the exchange rate and investment should be considered as interactive variables. Moreover, given the forward-looking perspective of investment decisions, it is important to use a framework that allows for potentially rich dynamics.

To account for both feedback and dynamic effects, we chose a VAR framework for our analysis. In VAR models, all variables are considered endogenous, and the analysis of dynamic structures can take many forms. Working with the autoregressive representation, Granger causality can be tested. On the other hand, using the moving-average representation, impulse responses can be estimated to evaluate shock dynamics. Although these properties are linked, they provide distinct and complementary information.[20]

3.1 Granger causality tests

Granger causality is a measure of the significance of one variable in forecasting another.[21] Within a VAR framework, Granger non-causality is characterized by a finite number of linear restrictions on a subset of parameters that can be easily tested. Although the characterization of causality is invariant to stationarity properties of the series, the statistical inference under non-stationary and/or cointegrated systems is driven by very irregular asymptotic properties for which the usual critical values remain valid only under special conditions (Sims, Stock, and Watson 1990; Toda and Phillips 1994).[22] To get around this problem, Toda and Yamamoto (1995) show that in non-stationary systems (where all the variables are I(1)), non-causality can be tested with variables in levels using the usual critical values.[23] This result holds whether the variables are cointegrated or not. Toda and Yamamoto make use of lag augmentation, that is, a VAR process of order $p + 1$ is fitted when the true order is p.[24] The tests are based on the estimated coefficient matrices associated with the first p lags only. Note that even though this methodology is asymptotically invariant, it can result in less powerful tests in finite samples (Yamada and Toda 1998).

Let $x_t = (x_{1t}, \ldots, x_{Nt})'$ be a vector of N time series for which we estimate a VAR of order p:

$$x_t = \sum_{k=1}^{p} \Pi_k x_{t-k} + u_t,$$

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[20] For example, non-zero impulse responses from one variable to another need not imply the presence of Granger causality, and vice versa (Dufour and Tessier 1993; Dufour and Renault 1998).

[21] More precisely, we say that a time series Y_t causes X_t conditional on variable Z_t in the sense of Granger if the observation of Y up to time t can help to predict X_{t+j} when the corresponding observations on X and Z up to time t are also used. Given that the information set includes only past observations, we can also interpret Granger causality as a notion of temporal precedence.

[22] For example, in the absence of cointegration, we can always estimate a VAR with the variables in first differences and perform the usual F-test.

[23] Unit-root tests are reported in Table 1. With the exception of the real investment measures, the three tests that we use do not give a unique characterization of the series. We follow Phillips's (1998) advice in such situations and consider these series as I(1).

[24] The order of the VARs that we estimate was determined by the Akaike criterion.

Table 1
Unit-root tests (1970Q1–2000Q1)

	ADF[a]	PP[a]	KPS[b]
ITOT [1]	0.0448	0.1736	1.531^{**}
IM&E [2]	1.2280	2.0522	1.695^{**}
FDI [3]	–1.9156	-6.9103^{**}	0.292
LRER [4]	–1.0464	–1.0064	1.104^{**}
MVOL [5]	–2.4747	-3.3849^{**}	0.417^{*}
PROF [6]	-3.4986^{**}	–2.3450	0.488^{**}
Critical values			
5%	–2.89	–2.89	0.463
10%	–2.58	–2.58	0.347

a. Null hypothesis is non-stationarity (unit root).

b. Null hypothesis is stationarity.

* indicates rejection of the null hypothesis at the 10 per cent level of significance.

** indicates rejection of the null hypothesis at the 5 per cent level of significance.

Augmented Dickey-Fuller (ADF) lags chosen by recursive estimation where insignificant lags are removed until a significant lag is found.

1. ITOT: ratio of total investment to GDP in real terms.
2. IM&E: ratio of M&E investment to GDP in real terms.
3. FDI: ratio of foreign direct investment to GDP.
4. LRER: real effective exchange rate.
5. MVOL: volatility of nominal exchange rate.
6. PROF: nominal profits to nominal GDP ratio.

where u_t represents the innovation process. The null hypothesis, $H_0: x_{it} \nrightarrow x_{jt}$, is characterized by the following constraints:

$$\pi_{ji,k} = 0, \quad k = 1, \ldots, p,$$

where $\pi_{ji,k}$ is the ji-th element associated with the matrix Π_k. The likelihood ratio statistic is used to infer non-causality:

$$\lambda_{LR} = 2[L(\hat{\Pi}) - L(\hat{\Pi}^0)],$$

where $L(\hat{\Pi})$ and $L(\hat{\Pi}^0)$ are the log-likelihood functions evaluated at the non-constrained and the constrained value of the estimator, respectively. Under the null hypothesis, the statistic λ_{LR} is distributed as a $\chi^2(p)$, where p corresponds to the VAR order.

Since our main objective is to estimate the dynamic relationship between various measures of investment and the real exchange rate,[25] we initially consider several three-variable systems that include the real investment to GDP ratio, either the level of the real exchange rate (LRER) or some estimate of misalignment, and our measure of exchange rate volatility (MVOL).[26]

Three different measures of investment are considered: total investment, machinery and equipment, and foreign direct investment. The data (at a quarterly frequency) span the 1970Q1 to 2000Q1 period. Note that the domestic investment ratios show a significant upwards trend, more than doubling over the sample period (Figures 1 and 2). The sharp rise in the investment ratios from the mid-1990s reflects the surge in computer-related investment and growth of "new" economy sectors. The direct investment flows are very choppy series (Figures 3 and 4). The 1990s saw a pronounced increase in both net inflows and outflows, reflecting the growing integration of the Canadian economy with the United States following the initial implementation of the FTA in 1989 and NAFTA in 1993. At first glance, these trends suggest that it might be difficult to support the proposition that the flexible exchange rate regime has had an appreciable negative effect on investment.

Two measures are considered in the examination of real exchange rate misalignments. The first is based on deviations of the real exchange rate from an "equilibrium" path as estimated by an H-P filter (MAHP). The second considers deviations from the dynamic simulation of a more recent variant of the Amano-van Norden (1995) exchange rate equation (MASD).[27] Since the latter is defined in bilateral terms, our measures of misalignments are defined in terms of the Canada-U.S. exchange rate.[28] Volatility is

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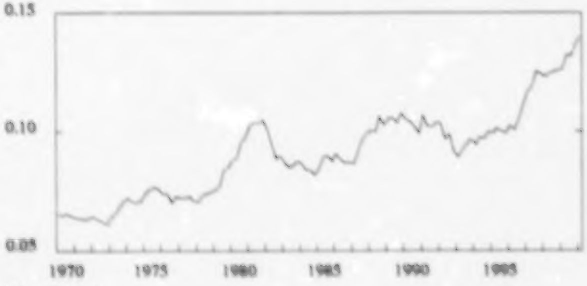
[25] While the exchange rate regime refers to nominal exchange rate arrangements, real investment flows are expected, in theory, to respond to real exchange rate movements. However, our measure of volatility is defined in terms of the nominal exchange rate, since GDP deflators are not available at monthly frequencies. In practice, this distinction may not matter, given the strong observed co-movements between nominal and real exchange rate measures (Finn 1999).

[26] Using the investment/GDP ratio has the advantage of removing the common trend that potentially affects these two variables. Furthermore, when investment and output are considered separately in the VAR, output accounts for almost all the investment dynamics. The strong co-movements between these variables are well understood in the literature, as noted by Shapiro (1986) among others.

[27] See Djoudad, Murray, Chan, and Daw (2001) for a fuller description of the equation.

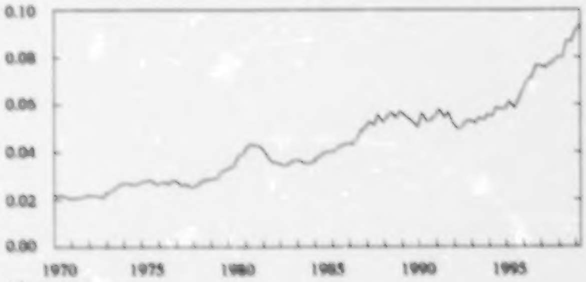
[28] Since the United States has a weight of 0.86 in the G-6 trade-weighted exchange rate index, there is little difference between the bilateral and the G-6 effective exchange rates for Canada. See Antia and Lafrance (1999) for a description of the G-6 index.

Figure 1
Total investment/GDP*



* In real terms

Figure 2
Machinery & equipment/GDP*



* In real terms

Figure 3
Foreign direct investment inflows/GDP

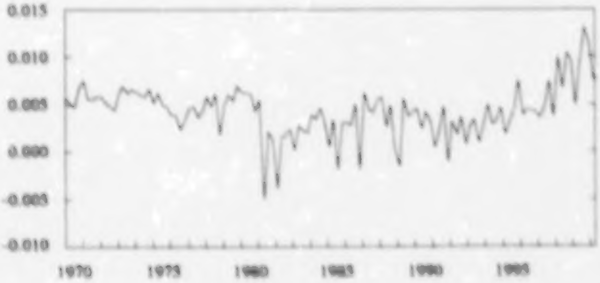


Figure 4
Foreign direct investment outflows/GDP

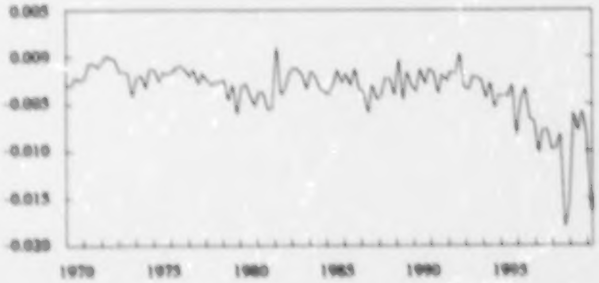
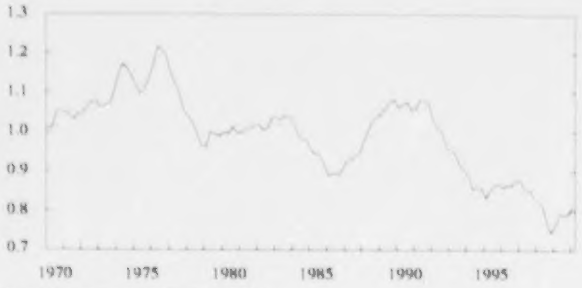


Figure 5
Real effective exchange rate (G-6)*



* Foreign currencies/Canadian dollar

Figure 6
Nominal exchange rate volatility

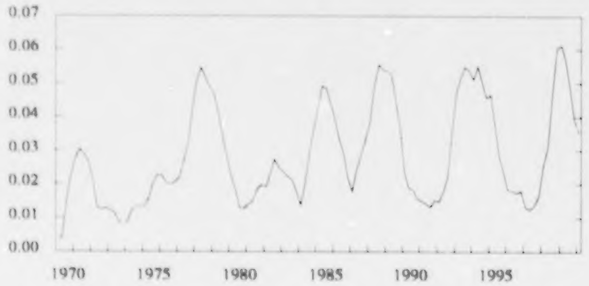


Figure 7
Misalignments

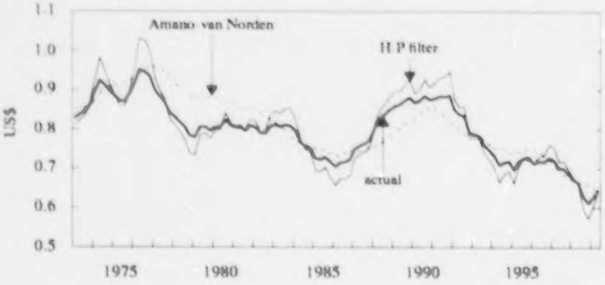
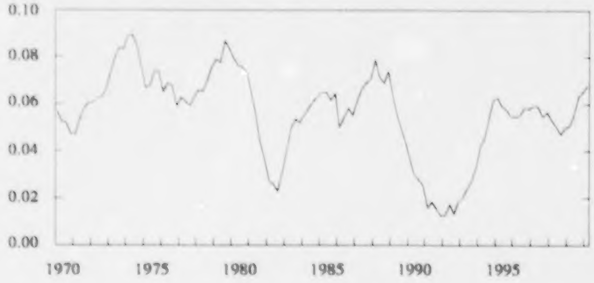


Figure 8
Profits/GDP



measured by the monthly standard deviation of the nominal effective exchange rate averaged over the previous 24 months.

Over the last 30 years, the Canadian dollar has depreciated by about 20 per cent in real effective terms, although not continually (Figure 5). The most pronounced and sustained period of depreciation occurred in the 1990s when investment ratios surged. Our measure of volatility exhibits periodic peaks and valleys, suggesting that investors might be able to set realistic bounds for the volatility of the Canadian dollar (Figure 6). The simulations of the H-P filter and the Amano-van Norden equation are shown in Figure 7. In the latter case, this is a dynamic simulation with estimates fitted over the whole sample period. Note that the two measures suggest different periods of possible over- or undervaluation of the Canadian dollar relative to the U.S. dollar, thus providing distinct ways to check for the influence of currency misalignments.

The results of the causality tests are presented in Tables 2, 3, and 4. The p-values indicate that, for all the VARs considered, we can never accept that volatility adds significant information content to the investment dynamics. The two measures of misalignment lead to a similar conclusion. Only the level of the real exchange rate appears to be causal, in the Granger sense, for investment. These results hold for all three measures of investment.

Granger causality considers only one-period-ahead predictability. However, given the forward-looking nature of investment decisions, testing for Granger causality over longer horizons is of interest. Dufour and Renault (1998) have generalized the notion of Granger causality to include any horizon h (up to infinity). Although testing for multi-step causality is complex, Dufour and Renault show that under special conditions, we can do multi-step tests by simply combining conventional one-period Granger causality tests.[29] Using this procedure, we find that exchange rate volatility or misalignments have no explicative power at any horizon for the investment dynamics (Tables 5 to 7).

But, as noted above, the notion of Granger causality depends on auxiliary variables that are included in the information set. Ignoring relevant variables can result in misspecifying tests and identifying spurious causality relationships (Sims 1980; Lütkepohl 1982). Thus, it is important to ensure that the results are robust to different information sets. Even though the best information set is the one that includes all the relevant variables, finite

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[29] In a trivariate system (X_t, Y_t, Z_t), the variable Y_t does not cause X_t conditional on Z_t for all horizons if Y_t does not cause both X_t *and* Z_t (Dufour and Renault 1998, Corollary 3.6, p. 1112).

Table 2
Three-variable VAR (I, LRER, MVOL)

H_0		p-value	
	Total	**M&E**	**FDI**
$LRER \nrightarrow I$	0.02	0.01	0.05
$MVOL \nrightarrow I$	0.91	0.99	0.22

Notes: LRER = real exchange rate level.
MVOL = exchange rate volatility.

Table 3
Three-variable VAR (I, MAHP, MVOL)

H_0		p-value	
	Total	**M&E**	**FDI**
$MAHP \nrightarrow I$	0.38	0.12	0.51
$MVOL \nrightarrow I$	0.70	0.55	0.11

Notes: MAHP = misalignment via H-P filter.
MVOL = exchange rate volatility.

Table 4
Three-variable VAR (I, MASD, MVOL)

H_0		p-value	
	Total	**M&E**	**FDI**
$MASD \nrightarrow I$	0.32	0.06	0.32
$MVOL \nrightarrow I$	0.48	0.27	0.22

Notes: MASD = misalignment via dynamic simulation.
MVOL = exchange rate volatility.

Table 5
Three-variable VAR (I, MVOL, LRER)

H_0		p-value	
	Total	**M&E**	**FDI**
$MVOL \nrightarrow LRER$	0.38	0.37	0.45

Notes: MVOL = exchange rate volatility.
LRER = real exchange rate level.

Table 6
Three-variable VAR (I, MAHP, MVOL)

H_0	*p*-value		
	Total	M&E	FDI
$MAHP \nrightarrow MVOL$	0.31	0.18	0.39
$MVOL \nrightarrow MAHP$	0.33	0.34	0.18

Notes: MAHP = misalignment via H-P filter.
MVOL = exchange rate volatility.

Table 7
Three-variable VAR (I, MASD, MVOL)

H_0	*p*-value		
	Total	M&E	FDI
$MASD \nrightarrow MVOL$	0.11	0.07	0.13
$MVOL \nrightarrow MASD$	0.25	0.22	0.18

Notes: MASD = misalignment via dynamic simulation.
MVOL = exchange rate volatility.

Table 8
Four-variable VAR (I, LRER, MVOL, PROF)

H_0	*p*-value		
	Total	M&E	FDI
$LRER \nrightarrow I$	0.59	0.30	0.12
$MVOL \nrightarrow I$	0.96	0.59	0.11
$PROF \nrightarrow I$	0.04	0.00	0.17

Notes: LRER = real exchange rate level.
MVOL = exchange rate volatility.

Table 9
Four-variable VAR (I, MAHP, MVOL, PROF)

H_0	p-value		
	Total	M&E	FDI
$MAHP \nrightarrow I$	0.68	0.27	0.49
$MVOL \nrightarrow I$	0.94	0.84	0.06
$PROF \nrightarrow I$	0.01	0.01	0.14

Notes: MAHP = misalignment via H-P filter.
MVOL = exchange rate volatility.

Table 10
Four-variable VAR (I, MASD, MVOL, PROF)

H_0	p-value		
	Total	M&E	FDI
$MASD \nrightarrow I$	0.58	0.20	0.37
$MVOL \nrightarrow I$	0.97	0.70	0.18
$PROF \nrightarrow I$	0.02	0.02	0.38

Notes: MASD = misalignment via dynamic simulation.
MVOL = exchange rate volatility.

samples impose a limit on the number of variables that can be considered in VAR models.

To check the robustness of our previous results, we consider undistributed corporate profits scaled by GDP (PROF) as an additional variable, since profits can represent the return on investment as well as the scope for internal financing, both of which would have a positive impact on investment. (Figure 8 gives the profile of undistributed corporate profits, which tend to fall dramatically in recessions.) The results are reported in Tables 8 to 10. The estimated p-values indicate that the level of the real exchange rate no longer has an effect on investment when profits enter the picture. Profits, however, are demonstrably linked to domestic investment flows given the very low p-values. Moreover, our previous conclusions regarding misalignments and exchange volatility continue to hold.

3.2 Impulse function analysis

Even though Granger causality analysis is a useful tool for analyzing dynamic structures between time series, it can't provide an estimate of the direction (sign) or magnitude of the relationships of interest. This is why

Sims (1980) proposed to invert the autoregressive part of the process and to work with the underlying moving-average representation.

The VARs are similar to the ones in the previous section. However, the inversion procedure calls for a stationary VAR process, which can be set up by differencing every integrated variable included in the system. After an appropriate orthogonalization of the reduced-form residuals, we can generate the impulse responses to the orthogonalized innovations. The moving-average representation of the process takes this structural form:

$$X_t = \sum_{k=0}^{\infty} \Theta_k u_{t-k} + w_t, \tag{1}$$

where the innovation process, w_t, has an identity covariance matrix. The elements of Θ_k are interpreted as responses of the system to the innovations. More precisely, the *ji*-th element of Θ_k is assumed to represent the effect on variable *j* of a unit innovation in the *i*-th variable that has occurred *k* periods ago.

To evaluate the potential impact of different shocks on investment, we consider the following contemporaneous causality structures.[30]

$LRER_t \rightarrow PROF_t \rightarrow I_t$ (Structure 1)

$VOL_t \rightarrow PROF_t \rightarrow I_t$ (Structure 2)

For these two three-variable systems, we are interested in shocks affecting the real investment measures (total and M&E). We consider exchange rate shocks (either in level or volatility terms) and profit shocks. Once we account for the confidence bands (outlined by the shaded areas), impulse functions for investment measures resulting from exchange rate shocks (either levels or volatility) turn out to be insignificant (Figures 9 to 12). In contrast, for all cases, profit shocks appear to have a significant impact on investment, with the expected positive sign (Figures 13 to 16).

We can thus summarize our empirical results:

- For all horizons, we can never accept the hypothesis that the measures of exchange volatility or misalignments add significant information (in the Granger sense) to the investment dynamics.

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[30] We also tested for the reverse order, and the results are qualitatively similar.

Figure 9
Shocks on M&E investment

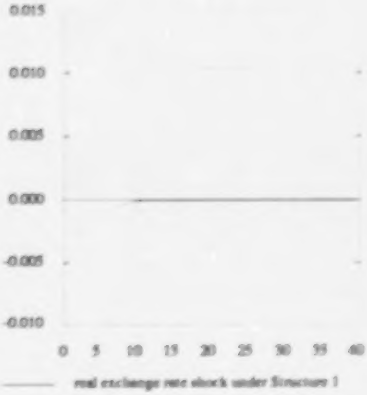


Figure 10
Shocks on total investment

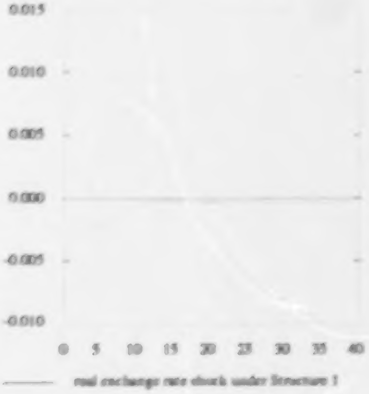


Figure 11
Shocks on M&E investment

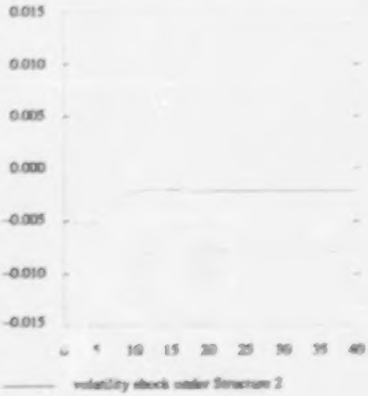


Figure 12
Shocks on total investment

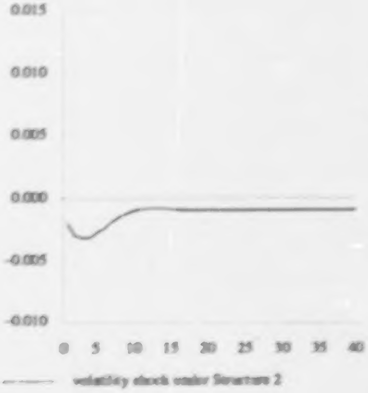


Figure 13
Shocks on M&E investment

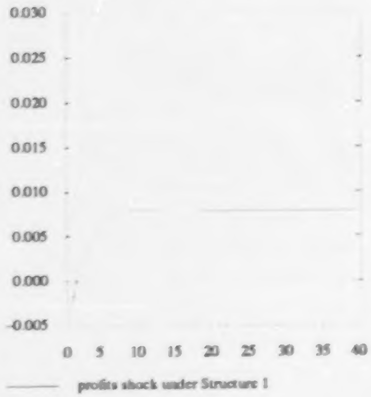


Figure 14
Shocks on total investment

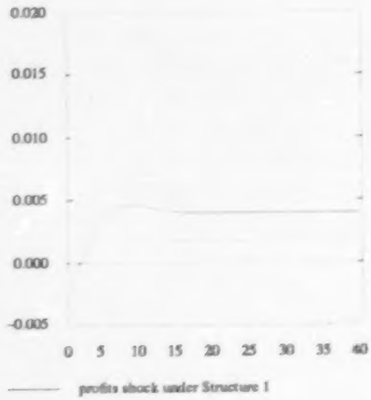


Figure 15
Shocks on M&E investment

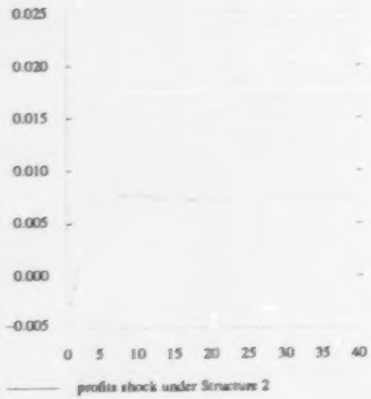
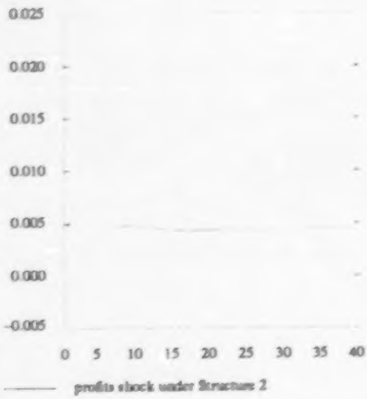


Figure 16
Shocks on total investment



- Even though the level of exchange rates appears to be causal for investment in small systems, the results are not robust to the inclusion of additional information (in our case, profits).
- These results are consistent with what we obtain from the impulse responses. All in all, we cannot find a statistically significant impact of exchange rate shocks on investment.

Conclusion

Our results do not support the position that excessive volatility or pronounced misalignments of the Canadian dollar over the more recent flexible exchange rate period have reduced in a detectable way the rate of investment in Canada or the degree of inward foreign direct investment. Our approach was to tackle this question from a macroeconomic perspective, without strong priors, using a VAR framework. The technique that we chose is admittedly simple, but it is also straightforward. By Ockham's Razor, it provides an unambiguous answer to the question that sparked this paper. Our negative results are also consistent with those of Campa and Goldberg (1999), who found, somewhat to their surprise, that the real exchange rate had no significant impact on investment for Canadian manufacturing sectors.

Even if we had found stronger and more significant effects of exchange rate variability on investment, it would still be difficult to make the case that a fixed exchange rate regime (short of a monetary union with the United States) would have produced more positive results. As IMF researchers noted some years ago, multinational firms may seek to diversify their investments across a number of markets that they serve in response to currency risk, even at some cost in terms of efficiency (IMF 1984). These long-term decisions will be based on prospective rather than current exchange rate variability. Firms will also prefer to invest in a country that has a well-established mechanism for adjusting its exchange rate, to ensure that domestic costs and prices do not get too far out of line with those abroad, rather than in a country where nominal exchange rate volatility is less but exchange rate stability results in more uncertainty about real exchange rates and, hence, profitability.

We recognize that one can never provide definite proof of a negative proposition.[31] We believe, however, that our paper adds to the body of evidence suggesting that exchange rate variability has no significant effect on investment in Canada.

Note: Following Linda Goldberg's comments at the conference, we tested for Granger causality in a three-variable VAR model that included the level of the real exchange rate, profits, and investment. For both total investment and M&E, the exchange rate did not Granger cause either profits or investment. This suggests that the exchange rate does not affect investment either directly or indirectly via its effect on profits.
—R. Lafrance and D. Tessier.

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[31] There is always the possibility that, under certain conditions, a negative effect on investment could be detected for other measures of volatility or misalignments for specific periods.

Appendix
Data Sources

Source: Statistics Canada, unless otherwise noted.

Private investment (in real terms)
— Non-residential structures & equipment (D14853)
— Machinery & equipment (D14855)

Nominal and real GDP
— Nominal GDP (D14840)
— Real GDP (D14872)

Foreign direct investment
— Foreign direct investment flows into Canada (D59062)
— Foreign direct investment outflows (D59052)

Exchange rate
— Real G-6 exchange rate (Bank of Canada)
— $US/$CAN (Bank of Canada)

Corporate profits
— Undistributed corporate profits (D16432)

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Discussion

Linda Goldberg

The main premise of this paper is that it is important to consider the effects of exchange rate movements on real economic activity in order to evaluate the implications of flexible exchange rates. To accomplish this task, Robert Lafrance and David Tessier focus on the responsiveness of investment activity in Canada to levels of the Canadian dollar and to the dollar's volatility. This dimension of real activity merits meticulous exploration, since investment fluctuations are an important component of levels and volatility of aggregate business cycles.

The authors have provided a well-articulated and carefully organized piece on the relationship between investment and exchange rates. Their paper begins with a thorough and thoughtful exposition of the competing arguments for profitability and investment effects arising from exchange rate movements. The authors also survey the existing evidence on this subject, noting those studies that are particularly relevant for Canada.

Beyond this literature overview, the main contribution of the paper is a detailed analysis of the link between Canadian investment and exchange rates. There are three types of aggregate investment measures examined: by manufacturing industries, by a subset of the manufacturing industries, specifically by machinery and equipment (M&E) sectors, and foreign direct investment activity, all taken relative to GDP. Although these measures will not provide a full perspective on the potential redistributive effects of exchange rates across sectors of the Canadian economy, they are appropriate for understanding aggregate investment fluctuations. A number of different exchange rate measures are also applied. They encompass the real effective exchange rate for the Canadian dollar, measures of exchange rate misalignments constructed using either a Hodrick-Prescott filter or an Amano-van Norden model, and a measure of nominal exchange rate volatility. While Lafrance and Tessier did not consistently use real exchange rates—and this type of consistency would be appropriate—I do not expect that any of the study's key results would be significantly altered by a full-scale shift to real realignments and real exchange rate volatility.

The paper's main methodological approach uses vector autoregressions (VARs) for identifying any significant causal effects of exchange rates. Ultimately, the authors conclude that exchange rates and their volatility have not really had much of an effect on Canadian investment activity. This type of finding is central to the paper and to the theme of the overall conference, in that it is highly relevant for "revisiting the case for flexible exchange rates." Implicit in the Lafrance-Tessier conclusion is that the detrimental effects of exchange rate volatility, which are sometimes evoked in arguments against flexibility, have not been evident in Canada. Before accepting this, however, it is necessary to look more carefully at the methodology, and to ask whether, as applied, it can deliver the conclusions presented by the authors.

The VAR methodology assumes a constancy in the relationship between exchange rate measures and investment measures over the time horizon of the analysis, almost 30 years. Consequently, it is worth going deeper into the analytics of this relationship to determine whether the assumptions underlying the empirical approach are well founded. From expositing the theory and by examining some additional empirical evidence, I conclude below that the tests performed in the Lafrance and Tessier paper are biased against finding statistically significant implications of exchange rates for investment. As I will describe, the extent to which this is a valid concern could be established by the authors through additional robustness and parameter stability tests. Regardless of the outcome of those tests, their paper suggests additional puzzles that are interesting and that warrant consideration.

On the issue of parameter stability, I appeal to a formal theoretical model of the links between investment and exchange rates. The authors are quite clear that it is not their goal to test a single theory of such linkages, and I am very sympathetic to this view. Nonetheless, this formality helps provide insight into the types of conditions that would have to prevail for the VAR to capture and measure the tightness of the actual relationship between the variables in question. In this regard, the theory helps identify the dimensions in which the VARs performed by the authors are adequately addressing the important potential effects of exchange rates.

The Theory

In a series of papers, Campa and Goldberg (1995, 1999) demonstrate how real exchange rates can enter the producer maximization problem. A firm chooses investment I to maximize the expected present value of the stream of future profits, V. Capital, K, the only quasi-fixed factor of production, is subject to a traditional capital accumulation equation and an increasing and convex cost of installing new capital. The maximized value of the firm at time t is given by:

$$V_t(K_t, e_t) = \max_{\{I_t\}_{\tau=t}^{\infty}} E\left[\sum_{\tau=0}^{\infty} \beta^{\tau}[\Pi(K_{t+\tau}, e_{t+\tau}) - c(I_{t+\tau}) - I_{t+\tau}]\middle|\Omega_{\tau}\right], \quad (1)$$

where K_t is the beginning of period t capital stock, Π is the profit function, β is the discount rate, I_t is the investment expenditure in period t, c is the capital adjustment cost function, e_t is the period t exchange rate expressed in terms of domestic currency per unit of foreign currency, and $E[\,.\,|\Omega_t]$ is the expectations operator conditional on the time t information set Ω_t. For simplicity, it is assumed that the only source of uncertainty about the future is the exchange rate, over which the expectation operator applies.

The timing of the model is as follows. The firm observes the exchange rate at the beginning of the period. The firm then chooses its variable inputs and output level for the period and observes the current profits. Given profits this period and expected future profits, the firm chooses its investment level. The new capital resulting from this investment becomes productive at the beginning of next period, i.e., under the assumption of a one-period time-to-build lag.

Suppose, too, that producer profits at any time t are driven by revenues from some domestic market sales—wherein the producer might face import competition—and by revenues from export sales abroad. Moreover, profits may be exposed to currency fluctuations through producer reliance on imported inputs into production.

Campa and Goldberg have derived the specific elasticity of a producer's investment with respect to exchange rates as proportional to:

$$\frac{\partial I_t}{I_t} \infty \left[\begin{array}{l} \left(\eta_{p,e} - \eta_{MKUP,e}\right)(1 - X_t) \\ + \left(1 + \eta_{p^*,e} - \eta_{MKUP^*,e}\right)X_t - \left(1 + \eta_{w^*,e}\right)\alpha_t \end{array} \right] \frac{\partial e_t}{e_t}, \qquad (2)$$

where $\eta_{p,e}$ and $\eta_{p^*,e}$ are exchange rate pass-through elasticities in domestic and foreign markets; $\eta_{MKUP,e}$ and $\eta_{MKUP^*,e}$ are markup elasticities with respect to exchange rate changes; X_t represents the share of total revenues associated with foreign sales ($(1 - X_t)$ is the share associated with domestic sales); and α_t, the share of imported inputs in production costs, is multiplied by the elasticity of these input costs with respect to exchange rates, $(1 + \eta_{w^*,e})$. The link between investment and exchange rates is tighter for exchange rate movements that are perceived as permanent.

Observe that the exchange rate affects expected profitability and therefore investment activity through three channels: (i) export market revenues, (ii) imported input costs, and (iii) home-market revenues. This third channel is intended to capture the possibility of import competition or the existence of wealth effects that potentially shift the demand schedule for domestically produced goods. These channels matter for interpreting the exercise of the Lafrance and Tessier paper. The profitability effects of exchange rates and consequent investment response could potentially be eliminated in the event that revenue effects are fully offset by import input cost effects. It is possible, but not at all guaranteed, that such a situation could arise when exporting occurs alongside a preponderance of multinational production activity or outsourcing activities and reliance on imported inputs. More generally, however, the relationship between exchange rates and investment (through the profitability channel) will vary over time to the extent that net external orientation varies. Here, producer net external orientation is the difference between revenue exposure and cost exposure. An absence of a relationship between investment and the exchange rate should be the exception, rather than the rule, for an externally exposed economy.

The Evidence

What do we know about Canadian net external orientation? As an indicator of net external orientation, consider the difference between the export share and imported input share of the subsets of Canadian manufacturing

Figure 1
Net external orientation:
Total manufacturing industries

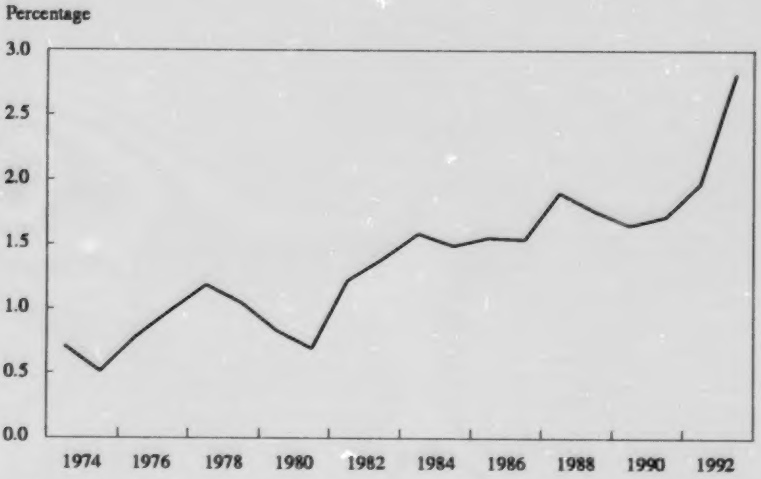
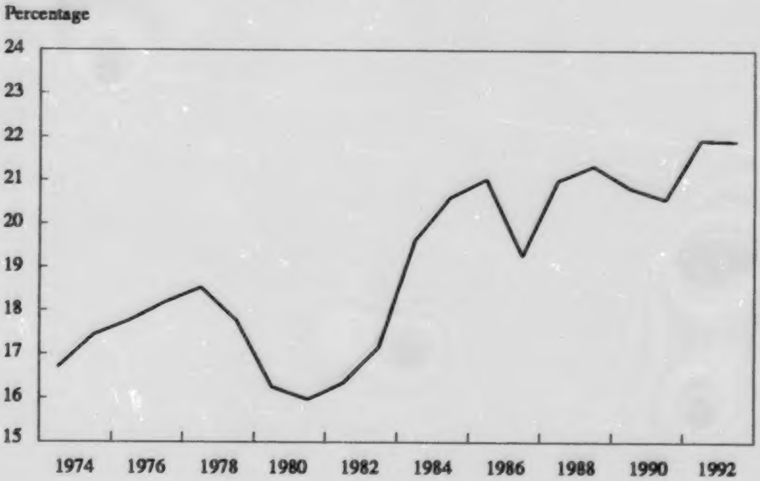


Figure 2
Machinery and equipment shipments
within total manufacturing shipments



considered by Lafrance and Tessier, i.e., all manufacturing and the M&E sectors within manufacturing (Figures 1 and 2).[1]

Observe that the net external exposure of Canadian manufacturing industries has more than tripled since the early 1970s. When the M&E sectors are considered, this indicator doubled by the early 1990s. Because of these extensive movements over time, from equation (2) we would expect that the effects of exchange rates on producer profitability and on investment would also be rising over time in Canada. Thus, a methodology that assumes a constant relationship—such as the VARs used in the paper—may understate the significant and evolving effects of exchange rates on Canadian investment.

This criticism still does not prove that in the data there exists a significant and identifiable link between exchange rates and investment in Canada. However, caution should be used in interpreting the current results, and further exploration of the data would be valuable. Additional and more extensive robustness checks are also warranted.

If the Lafrance and Tessier conclusions hold true—indeed, Campa and Goldberg (1999) also couldn't find significant effects of Canadian exchange rates on industry-level investment—a broader puzzle exists for Canada. Consistent with the VAR structure of Lafrance and Tessier, exchange rates should drive profits, which, in turn, should drive investment. If the link between exchange rates and investment is insignificant, how can this be explained? Is it because exchange rates don't matter for the profitability of Canadian manufacturers—an outcome I would find highly unlikely—or is it because profitability does not matter for Canadian investment? If the authors were to argue that exchange rates can affect producer investment above and beyond the profitability channel, they could explore these questions conceptually and empirically.

Concluding Remarks

The authors have put together a very insightful and thought-provoking discussion of whether the behaviour of the Canadian dollar has significant effects on Canadian investment spending. While the jury is still out on the final answer to this question, the authors have made important progress towards its resolution. If, as currently concluded, the answer is "no," then other puzzles emerge. Indeed, it would be surprising if investment in as open an economy as Canada were truly insulated from exchange rates.

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[1] Campa and Goldberg (1997) provide a more extensive discussion of the exposure of specific Canadian manufacturing industries. The data from that paper were used for creating Figures 1 and 2.

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Is There a Case for Exchange-Rate-Induced Productivity Changes?

*Richard G. Harris**

Introduction

In "traditional" open economy macroeconomic theory, productivity growth is taken as exogenous relative to changes in the nominal exchange rate or in the exchange rate regime. The idea, however, is frequently raised that movements in the exchange rate can have an impact on productivity. One mechanism that focuses on demand-side effects, often referred to as the competitiveness approach, emphasizes the export growth effect of an exchange rate depreciation and the productivity consequences of that growth.[1] Another heterodox stream of literature, which focuses on the supply-side consequences of a sustained real exchange rate depreciation, argues that it can contribute to lower productivity growth and a larger productivity gap between the depreciating country and the leading countries. This is actually quite an old idea among policy-makers, central bankers, and businessmen and was one of the reasons a nation would prefer a "hard currency." Porter (1990), in his well-known book on global competitiveness and growth, pointed out that depreciations can reduce growth, and an overvalued exchange rate can sometimes contribute to productivity growth

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1. Boltho (1998) discusses the history of the competitiveness view of the exchange rate and the important role it has played in economic policy discussions on economic growth in Europe.

* This is a substantially revised version of the paper presented at the Bank of Canada conference *Revisiting the Case for Flexible Exchange Rates.* I am indebted to Soren Halvorsen for excellent research assistance, to Serge Coulombe and my discussant David Longworth for their comments on the conference version of the paper, and to the conference participants.

by forcing productivity increases in the tradables sector. This idea occasionally finds its way into official policy. Singapore, for example, had a long period of deliberate appreciation of the exchange rate with a stated intention of forcing competitive productivity increases (see Lu and Yu 1999).

Over recent years, the productivity case has become central to the debate in Canada on the causes and consequences of the significant real depreciation of the Canadian dollar in the 1990s. Part of this paper will look at the Canadian productivity issue and ask whether it casts some light on the link between productivity and the exchange rate. Courchene and Harris (1999) and Grubel (1999), among others, have argued that the substantial depreciation of the Canadian dollar during the 1990s contributed to the well-documented widening productivity gap between Canada and the United States.[2] The proximate and ultimate sources of the productivity gap have been widely discussed in Canadian economic policy literature. Figure 1 and Table 1 present alternative perspectives. Figure 1 uses aggregate GDP as an output measure and clearly indicates the dramatic decline in Canadian productivity performance relative to that of the United States. A slightly less alarmist perspective is provided in Table 1 from Gu and Ho (2000) on comparisons of the Canada-U.S. manufacturing sectors.

This table indicates a substantial gap opening up between Canadian and U.S. productivity over the 1979–95 period, particularly on a value-added basis. The gap in total factor productivity (TFP) growth is also significant but not as dramatic. This suggests determinates other than TFP may have been responsible for the differences in labour productivity growth, including greater outsourcing in the United States, larger quality changes in the inputs, and stronger growth in capital.

It is traditional to argue that productivity changes cause real exchange rate changes. This is the well-known Balassa-Samuelson hypothesis, which states that higher productivity growth in the tradables sector should lead to a long-run increase in the real exchange rate.[3] Lafrance and Schembri (2000), in their recent review of the Canadian case, argue that there is no evidence to suggest a link running from exchange rate depreciation to a widening productivity gap between Canada and the United States, but they suggest that the Balassa-Samuelson mechanism may be evident in the data. That is, Canada's lagging productivity performance in the manufacturing sector may

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[2] This paper does not discuss possible causes of the real depreciation of the Canadian dollar. This remains an active and unresolved debate.

[3] Strauss (1999) provides recent evidence on the Balassa-Samuelson hypothesis based on a time-series multi-country approach. He finds no evidence for causality running from productivity to real exchange rates, but some evidence of the reverse.

Figure 1
Relative labour productivity: Canada vs. the United States

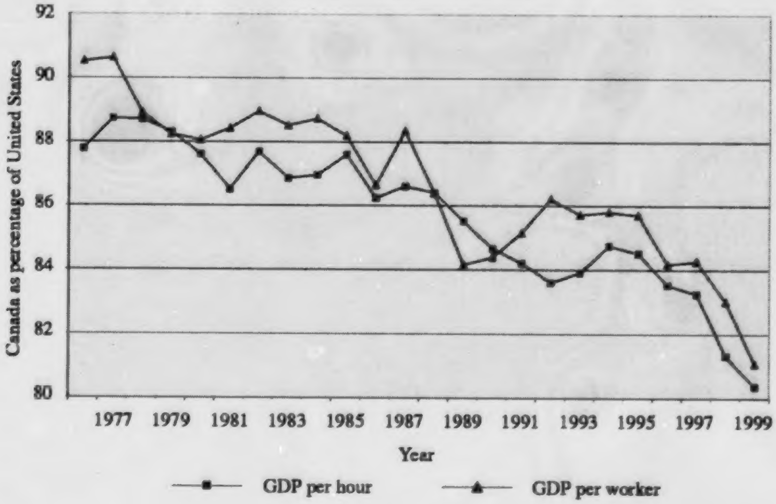

Table 1
Productivity and output growth comparisons
Manufacturing in Canada and the United States

	Canada		United States	
Period	**1961–95**	**1979–95**	**1961–95**	**1979–95**
Gross output	3.48	1.97	2.79	1.73
Capital stock contribution	0.22	0.143	0.24	0.17
TFP	0.55	0.28	0.86	0.80
Labour productivity (value-added)	2.55	1.83	3.17	3.00
Labour productivity (gross output)	2.75	2.28	2.37	2.32

Source: Gu and Ho (2000).
Note: Capital and labour inputs are quality adjusted.

be contributing to the observed real exchange rate depreciation relative to the U.S. dollar.

Harris (2000) argued that there are good reasons to treat productivity as endogenous within a macroeconomic framework in which the exchange rate regime is either fixed or floating. The motivation for this observation is drawn from endogenous-growth theory, including the recent work on general purpose technologies (GPTs) or large-scale systemic technological revolutions and recent business cycle theory. The competitiveness approach emphasizes that real exchange rate depreciations accelerate productivity growth in certain circumstances. This would be consistent with substantial theoretical literature on the procyclical productivity effects of demand shocks. For example, in many macro models of the New-Keynesian variety with nominal rigidities, a positive demand shock can increase measured productivity growth through increased factor utilization, learning-by-doing effects (the Verdoon hypothesis), or increasing returns to scale. A real exchange rate depreciation, which increases the demand for tradables, would tend to exhibit similar effects in that sector. There is an active empirical debate (see Basu 1998 and references) regarding how permanent the productivity consequences of demand shocks are. There is a related literature arguing the opposite link between cycles and productivity. Reorganization or "cleansing recession" are cited as reasons that a cyclical downturn could lead to productivity increases, although again, the evidence appears mixed.[4] One could also apply these types of theories to real exchange rate shocks.

The Canada-U.S. experience of the 1990s suggests another causal channel that is of current policy interest and may be unique in the historical sense: the arrival of the New Economy. A small open economy under a floating exchange rate may face a structural transition problem when its major trading partner has forged ahead on its own major technological transition. If the United States is in the midst of a major technological transition driven by a convergence of computers and information technology—the IT revolution—the pace and manner in which Canada adapts to this major GPT[5] is critical for its longer-term growth performance. It is widely acknowledged that the United States leads the IT transition,[6] while Canada has lagged and continues to export and specialize in more traditional Old Economy sectors.

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[4] Some of the recent literature includes Hall (1991), Caballero and Hammour (1992), and Saint-Paul (1993).

[5] For a discussion of GPTs, see Helpman (1999); for a broad historical discussion, see the survey by Lipsey, Bekar, and Carlaw in that volume.

[6] Robert Gordon (1999) surveys this evidence as of mid-1999 and is a well-known critic of the New Economy hypothesis. As of mid-2000, acceleration in the growth of U.S. labour productivity remains intact.

The 1990s were also characterized by a significant decline in resource prices (the Old Economy, if there ever was one). Canada was thus hit with two simultaneous shocks in the 1990s: (i) a decline in Old Economy prices or resource prices and (ii) the arrival of a new major GPT. If the exchange rate *buffers* the Old Economy through an accommodating real depreciation, this may lead to a slower rate of economic growth and, possibly, a permanently lower level of real income relative to a non-buffered exchange rate path. In effect, there is a slowdown in creative destruction in the Old Economy due to the exchange rate depreciation.

These explanations are not the only, or necessarily the most important, means by which a sustained depreciation may raise or lower long-term growth. Section 1 reviews three potential and now standard explanations for the Canada-U.S. productivity gap in light of the sustained real exchange rate depreciation of the Canadian dollar over the last decade. These are three "smoking guns" in the productivity-exchange rate debate. In each case, there are good a priori reasons to link the productivity driver to the exchange rate depreciation. It has admittedly been impossible to conclusively prove, with statistical methods, that these factors are the main reasons for the Canada-U.S. productivity gap, but they currently stand as the best explanations we have.

One can imagine other mechanisms through which a serious and persistent exchange rate undervaluation might raise productivity growth. For example, if there is a persistent real undervaluation that results in a sustained cost advantage to the country in question, this could lead to a relatively long period of superior export performance. A variety of dynamic theories familiar from the infant-industry literature can be used to link this superior export performance to a superior productivity performance. This argument was made in the context of the misalignment literature of the 1980s, which was largely a response to the dramatic swings in the U.S. dollar over that decade.[7] From a theoretical perspective, therefore, a trend depreciation that gives rise to a sustained undervalued exchange rate, as measured by some index of misalignment, may have positive or negative productivity consequences.

Given the multiplicity of factors and theoretical ambiguity relating productivity growth and exchange rates, the 1990s depreciation of the Canadian dollar will not prove or disprove the general hypothesis that persistent exchange rate depreciations contribute to productivity gaps. For this reason, it is useful to go beyond the Canadian 1990s experience and use international cross-country evidence to determine whether there is any evidence for the hypothesis in the wide range of productivity-growth experiences of industrial countries. Section 2 presents a panel study of productivity growth in manufacturing industries in the Organisation for Economic Co-operation and Development (OECD). The basic empirical framework starts with a well-known conditional convergence productivity-growth equation used in many studies. This equation, motivated by endogenous growth in open economies, states that productivity growth is related to a convergence term, openness, and investment. Within this framework, we look for possible effects of sustained exchange rate misalignment on productivity growth at the country and industry levels. The measure of exchange rate misalignment is a conventional and easily measurable one defined by purchasing-power parity (PPP) benchmarks for the equilibrium exchange rate. In traditional models, exchange rate depreciations boost exports and import-competing output. These short-run output effects can also have positive productivity consequences through increased capacity utilization of fixed inputs and through dynamic scale economies. This alternative "competitiveness" view of the exchange rate and productivity link is also examined. In general, the evidence supports both transmission channels for open economies, but the positive competitiveness effects from a depreciation are transitory, while the misalignment effects tend to be much longer lasting and negative. The final section offers concluding comments.

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[7] The trade effects of misalignment is the subject of a fairly extensive literature—both theoretical and empirical. An overview from the Canadian perspective is provided in Harris (1993).

1 Depreciations and the Canada-U.S. Productivity Gap: Three Smoking Guns

That a change in the real exchange rate could have productivity effects is consistent with a wide range of endogenous-growth models. The direction of the effect, however, will vary with the model used. This paper does not provide a comprehensive general-equilibrium theory of the co-movements in the exchange rate and productivity growth. That would require a specific theory of exchange rate determination and, as is well known, there is no consensus on what that theory might be. The focus is on the more limited question of whether there is a causal link between real exchange rate movements to medium-term productivity growth. It is entirely possible that this structural link is consistent with a long-run growth model in which the causality runs in both directions.

The focus here is on three explanations for a weak productivity growth performance—the three smoking guns that have emerged from the Canadian productivity debate—and their links to the exchange rate. Each of these explanations is consistent with at least one class of endogenous productivity growth models. The smoking guns are the factor-cost effect, the innovation-gap hypothesis, and the slowdown in creative destruction.

1.1 The relative factor-cost hypothesis

Canada's investment in machinery and equipment (M&E) has lagged behind that of the United States in recent years, in the nominal spending share relative to GDP and in real terms. The spending share of nominal M&E investment relative to GDP has averaged 11 per cent below its share of GDP, in comparison with the United States over the same period. From 1980 to 1996, Canada ranked fourth from bottom amongst the OECD in terms of its M&E spending relative to GDP.[8] This has direct and indirect effects on productivity. Important evidence to emerge from the Canadian productivity debate is provided by the work on TFP growth versus labour productivity in Canada. U.S. studies by Sharpe (1999), Gu and Ho (2000), and Lee and Tang (1999) show clearly that the labour productivity gap between Canada and the United States is due, in part, to a fall in the rate of capital formation in Canada relative to the United States and, to some extent, to a TFP gap. In sectors where a TFP gap has persisted, there are strong reasons to believe this may be related to a difference in the investment intensity of Canadian versus U.S. industries. as discussed by Rao, Ahmad, and Kaptein-Russell (2000). There is substantial evidence, for example, that TFP growth is directly related to investment in M&E.[9] In the Canadian manufacturing sector over the 1991–97 period, the level of investment in M&E per hour worked (referred to as the investment intensity) fell significantly behind that of the United States after being at comparable levels in the late 1980s. By 1997, the Canadian-U.S. manufacturing investment intensity gap was 40 per cent. This dramatic deterioration in Canadian M&E investment contributes significantly to Canada's lagging productivity growth. The obvious question is why. One answer is almost certainly the relative rise in the price of new M&E that has accompanied the depreciation of the Canadian dollar.

One way to illustrate this is to compare the rental/wage (r/w) ratio in the two countries over the last decade. This comparison points to dramatically different trends. In Figure 2, (r/w) for Canada is drawn relative to that of the United States. From the end of 1991 to the end of 1999, the Canadian (r/w) ratio rose by 30 per cent relative to the United States. With the global fall in M&E prices, the r/w ratio fell in both countries. But Canada's modest decline pales next to that of the United States, where, from 1991 to 1999, the r/w ratio fell by 36 per cent. Since approximately 80 per cent of Canadian M&E is imported—and the bulk of that from the United States—a substantial portion of this difference is directly attributable to the fall in the Canadian dollar over the same period.

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[8] An alternative explanation may hinge on tax differences between the two countries. A recent OECD study by Gordon and Tchilinguirian (1998) notes that the effective subsidy to M&E in the United States is equivalent to a reduction of 4.4 per cent in the required rate of return on these investments. In contrast, the effective tax rate in Canada on M&E investments raises the required rate of return about 1.4 per cent.

[9] There is substantial literature on investment and productivity growth. The standard reference is De Long and Summers (1991).

The factor-cost hypothesis is broadly consistent with both exogenous- and endogenous-growth theories. In an open economy Solow-type model, if capital goods are imported, a rise in the price of those imports will use labour for capital substitution and lead to slower growth in average labour productivity, even if there is no impact on TFP growth. In a wide range of open economy endogenous-growth models, there is the potential for an additional effect of slowing investment on TFP growth. One theory, which is perhaps the simplest, comes from Lee (1996); it features an open extension of the A-K type model in which capital goods are imported. Lee finds strong evidence of changes in equipment prices on growth rates of per capita GDP, and this supports earlier findings of De Long and Summers (1991).

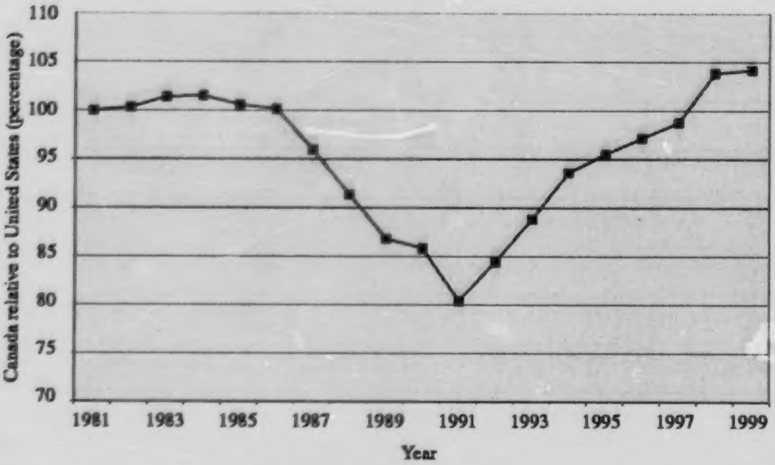
A different perspective on the factor-cost hypothesis is provided by recent evidence in an International Monetary Fund (IMF) report on Canada (see Dunaway et al. 2000) and in work by Carlaw and Kosempel (2000). These studies use the methods of Greenwood, Hercowitz, and Krussel (1997) to decompose TFP growth into investment-specific technological (IST) change and conventional residual-neutral technological (RNT) change. The studies argue that IST accounts for improvements in the quality of capital, since it captures technological advancements embodied in new M&E, such as innovations in information and communications. This perspective has quite a dramatic effect on the interpretation of Canadian TFP numbers. Table 2 summarizes the Carlaw-Kosempel measures of IST and RNT relative to TFP over selected periods.

Table 2
Average annual growth rates: Productivity and technology Canada 1961–96

Period	1961–73	1974–96	1961–96
Total-factor productivity	1.75%	0.17%	0.71%
Investment-specific technology	1.29%	5.12%	3.81%
Residual-neutral technology	1.80%	–0.07%	0.57%

Source: Carlaw and Kosempel (2000).

Figure 2
Relative factor prices
Price of machinery and equipment/wage rate
Canada vs. the United States: 1981–99



The average annual rate of IST accelerated from 1.29 per cent over the 1961–73 period to 5.12 per cent over the 1974–96 period. In comparison, the average annual rate of RNT declined from 1.80 per cent over the 1961–73 period to –0.07 per cent over the 1974–96 period. Carlaw and Kosempel quantify the individual contributions of IST and RNT to the rate of TFP growth in Canada, using a calibrated aggregate-growth model. They find that IST accounted for approximately 20 per cent of the growth in TFP over the entire 1961–96 period, zero per cent over the pre-1974 period, and 100 per cent over the post-1974 period. RNT accounted for the remainder in each period. Since IST is strictly driven by investment in M&E, any factor that would cause that investment to slow would have a strong and direct effect on productivity growth. In an open economy that imports the bulk of its capital goods, the supply-side consequence of a sustained rise in the prices of imported investment goods would be considerable. Moreover, the effects of differing investment intensities across countries, as in the Canada-U.S. case, will ultimately show up in the form of differential TFP levels. The recent poor investment performance of Canada in this regard does not bode well for future TFP-level comparisons with the United States, even if current comparisons do not indicate a problem.

1.2 The innovation-gap hypothesis

The Canada-U.S. productivity gap has been attributed by a number of observers to the existence of an "innovation gap" between Canada and the United States. The OECD (1998), Trefler (1999), Fortin (1999), and Trajtenberg (1999) all suggest that a poor R&D and innovation performance can explain Canada's lagging productivity growth. Again, proving this is easier said than done. But the smoking gun is evident. Trajtenberg makes the following points.[10]

(i) Canada stands well below the other G-7 countries (except for Italy) in terms of the relative amount of resources devoted to innovation, with a R&D/GDP ratio of 1.5 per cent, as opposed to 2.0–2.8 per cent for Germany, Japan, and the United States.

(ii) The "rate of success" of Canadian patent applications in the United States is low relative both to the other G-7 countries and to smaller technology leaders such as Finland, Israel, and Korea.

(iii) The technological composition of Canadian patents is out of step with the rest of the world, particularly in the fields of computers and communications, and electrical equipment and electronics.

(iv) The patterns of ownership of Canadian patents are also troubling: less than one-half of Canadian patents are owned by Canadian assignees. Half of Canadian inventions may not fully benefit the Canadian economy, either because they are done by individuals who have a difficult time commercializing them, or because they are owned by foreign assignees.

(v) There is a significant gap of about 20 per cent in the "quality" or "importance" of Canadian patents versus patents of U.S. inventors, as measured by the number of citations received. The quality gap resides first and foremost in computers.

Related evidence on the innovation-gap hypothesis is the slow TFP growth of the two high-tech industries: industrial machinery and electrical equipment. Gu and Ho (2000, Table 8) estimate that in Canada these two sectors account for 90 per cent of the TFP growth gap between Canadian and U.S. manufacturing for the 1979–95 period, reinforcing similar conclusions from Sharpe (1999). Obviously, the source of this innovation gap is due to a number of causes, of which the exchange rate depreciation may only have been a partial or complementary factor. The large depreciation, however, could have been a contributing cause through at least three channels.

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[10] This is a summary of the argument as presented in Trajtenberg (1999).

(i) A great deal of technology is imported from the United States including, notably, computer equipment. As in the case of the factor-price hypothesis, to the extent these costs are in U.S. dollars, the depreciation raised the absolute Canadian dollar cost of innovation in Canada in both the service and manufacturing sectors.

(ii) The IT boom in the United States, coupled with a fall in the Canadian dollar, lowered the U.S. dollar wages of IT and other high-tech workers in Canada relative to what they are paid in the United States. This may have contributed to the "brain drain." And the brain drain, in turn, could have (a) slowed down the rate at which new technology was absorbed in Canada and (b) in the case of "creative brains" who migrated, the drain may have led to innovations occurring within a U.S.-based firm as opposed to a Canadian-based one.

(iii) The depreciation may have led firms to shift resources from productivity enhancement to output expansion. Saint-Paul (1993) has developed a model of endogenous productivity growth in which firms in the short run must substitute between productivity-enhancing activities (process and product innovation) and output expanding activities. This theory would imply that a series of exchange rate depreciations, all of which were thought to be temporary, would cause profit-maximizing firms to expand output in response to the depreciation, at the expense of R&D, etc. This intertemporal substitution effect would have been most pronounced in those export and import competing sectors that could build market share through price competition rather than in sectors where product innovation is a more important competitive strategy. As discussed by Trefler (1999), the export and output data for Canada show a clear pattern of growth in the traditional sectors—including resources—relative to sectors where innovation has been more important.

1.3 A slowdown in creative destruction

The emerging New Economy paradigm in the United States suggests that we are in a major technological transition driven by a convergence of computer technology, the Internet, and a wide range of IT innovations. The acceleration in the U.S. productivity data after 1995 is the principal macro evidence supporting the hypothesis that a major new GPT (the IT revolution of the New Economy) is driving economic activity in the United States. From 1972 to 1995, output per hour in the U.S. business sector grew at 1.27 per cent. From 1995 through the end of 1999, it grew at 2.65 per cent. This acceleration, and the lack thereof in Canada, suggests that the process of creative destruction may have been thwarted to some extent in Canada. There are two issues here worth thinking about—the small-firm problem and declining industry.

A large number of U.S. studies have identified firm-level heterogeneity in productivity and the entry and exit process as major sources of productivity growth. Foster, Haltiwanger, and Krizan (1998) claim that 40 to 50 per cent of all productivity growth in some industries is due to entry and exit effects. In contrast to the United States, however, the distribution of employment by firm size in Canada has shifted substantially towards small and medium-size firms. The productivity debate in Canada has consistently identified the prevalence of small firms in Canada as a proximate contributing factor to the Canada-U.S. productivity gap. Canada has a size distribution of firms much different from that of the United States, with a much larger fraction of output accounted for by small firms. A series of studies reviewed by Daly, Helfinger, and Sharwood (2000) suggest that the persistence of these small firms may have contributed to Canada's productivity gap vis-à-vis the United States.[11] The orders of magnitude are considerable. Daly, Helfinger, and Sharwood present the following data (Table 3), using value added per production worker as the measure of productivity in both countries. The Canada-U.S. differences in plants with less than 100 employees are striking.

Table 3
Relative productivity of
Canadian vs. U.S. plants by size class

Plant size (no. of workers)	1977	1987	1999
500+	108	105	114
1–100	69	58	57
All plants	90	79.6	82.4

Source: Daly, Helfinger, and Sharwood (2000).

The persistence of a Canadian size distribution heavily weighted towards small firms awaits a coherent theoretical explanation, but a large (possibly unanticipated) exchange rate depreciation almost certainly contributed to a slowdown in creative destruction in the small-firm sector. Two channels are possible.

(i) Small firms are often constrained in the capital market and heavily affected by changes in cash flow. An exchange rate depreciation that raises profits will tend to reduce the rate of exit of cash-constrained incumbents. At the same time, the depreciation raises the cost of entry to firms that need either new technology and or have large fixed costs based on imported inputs. This can slow the overall rate of productivity growth by shifting output growth from high to low productivity sectors.[12]

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[11] This evidence is reviewed in Harris (1999).

(ii) Grubel (1999) has noted that previously marginal entrants in contestable industries (easy entry and exit) find it profitable to enter with an exchange rate depreciation driving down productivity growth in the industry, since more output is accounted for by plants with low productivity levels.

(iii) Entrepreneurship and human capital can respond to exchange rate changes. A real depreciation can reduce the returns to skilled labour via Stolper-Samuelson effects if the tradables sector is human-capital intensive relative to the non-tradables sector; it can also induce entrepreneurial or skilled labour out-migration if factors are sufficiently mobile and responsive to exchange-rate-induced real-income decreases.

When the pace of creative destruction is potentially uneven across sectors, an additional source of productivity growth is the ability to shift resources from slow- to fast-growing sectors. The 1990s may have been unique in that the decade witnessed a period of larger scale technological change at a global level, brought about by the arrival of what has become known as the New Economy. Creative destruction in the Old Economy is an important and necessary feature of the technological transition induced by a major new GPT. In the case of Canada, the negative shock to the Old Economy was exacerbated by the decline in natural-resource prices. If, under a managed or flexible exchange rate regime, such a shock results in a trend real depreciation, this may tend to delay technological adoption and encourage output growth in Old Economy sectors, reinforcing old patterns of comparative advantage and lowering growth rates. This raises the troubling scenario that while the initial depreciation appears to be a temporary equilibrium response to the Old Economy shock, it induces a permanently lower equilibrium exchange rate due to reduced productivity growth that initial depreciation gives rise to. The misalignment is thus temporary, but the real depreciation becomes permanent.[13]

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12. Grubel (1999) has raised this argument in the case of the resource sectors in Canada.
13. A theoretical model of this process is described in Harris (2000).

2 An Econometric Model of Exchange Rate Misalignment and Productivity

The simultaneous increase in the Canada-U.S. productivity gap and the trend depreciation of the Canadian dollar do not prove that the exchange rate depreciation contributed to the productivity gap.[14] Other country case studies would be useful to see whether similar factors are at work. The cases of New Zealand and Australia might be instructive in this regard, particularly if contrasted with other resource exporters who were either on fixed rates or had a long-run trend real exchange rate appreciation (e.g., Norway or Finland). In this section, however, we look to cross-country/cross-industry data for evidence consistent with the hypothesis that large depreciations slow productivity growth. To do this, one needs a benchmark model of productivity growth that has support in the literature. One widely used model is the conditional productivity convergence model, which has been used at both the aggregate and industrial levels in a large number of international and industry comparison studies. Examples include Bernard and Jones (1996); Bernard and Jensen (1999); Cameron, Proudman, and Redding (1998); Carree, Klomp, and Thurik (2000); and Harris and Kherfi (2000). The model has been used to examine a range of issues that include the speed of convergence, trade specialization, human capital and foreign direct investment spillovers, and export concentration.

The basic productivity-growth equation for industry i in country c is as follows:

$$\Delta A_{ic}(t)/A_{ic}(t) = \alpha_{ic} + \gamma X_{ic}(t) + \beta\frac{(A_i^*(t-1) - A_{ic}(t-1))}{A_{ic}(t-1)}.$$

The dependent variable is the change in productivity in industry i in country c in time period t. This is dependent on some fixed effects (both country and industry) and some general effects as measured by the set of variables X. The convergence effect is reflected by the productivity-gap term on the end of the right-hand side of the equation. β is the (positive) coefficient of the conditional convergence coefficient that reflects the extent to which international catch-up contributes to an industry's productivity growth. Catch-up is relative to the average productivity across all countries for that industry defined by A_i^*. This equation is viewed as being broadly consistent with a number of endogenous productivity-growth theories. Explanatory variables that are presumed to cause productivity growth (the *X*'s) include R&D, investment, openness, human-capital intensity, and trade specialization. The benchmark model used in this paper includes investment and openness.

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[14] McCallum (1999) notes the correlation between productivity growth in Canadian manufacturing and lagged quarterly changes in the Canada-U.S. exchange rate. This correlation is, however, almost entirely dependent on a single event: the depreciation of the 1990s. Statistical inferences from these types of aggregate correlations in single-country time series are notoriously fragile.

2.1 Two exchange rate effects: Misalignment and competitiveness

In line with the discussion of the last section, two explanatory variables are included that reflect exchange rate channels. To implement them, we define an exchange rate misalignment variable using a trade-weighted PPP benchmark to measure the divergence of the current exchange rate from its long-run equilibrium value based on economic fundamentals.

The first productivity-exchange rate link is the competitiveness hypothesis. This model focuses on the idea that the major source of productivity is output growth or increases in market shares. To the extent that both of these are driven by price competition, theory would predict that exchange rate depreciation contributes to an increase in "international price competitiveness," and this increases output growth and improves productivity. The competitiveness effect is captured empirically by the most recent one-year change in the degree of misalignment. Since PPP benchmarks move relatively slowly, this will largely reflect the most recent change in the nominal and real exchange rate.

The second set of effects emanates from a relatively permanent or long-lived departure of the exchange rate from its equilibrium value as measured by the level of the exchange rate relative to a long-run equilibrium real exchange rate. As discussed in the previous section, a range of supply-side effects come into play from a seriously misaligned exchange rate that could have a negative or positive effect on productivity growth. As in the misalignment literature, one needs some measure of an equilibrium exchange rate in order to measure the divergence of the actual exchange rate from the equilibrium rate: the degree of misalignment. There has been no unique resolution in the misalignment literature as to how this should be done. Concepts such as the Fundamental Equilibrium Exchange Rate or other structural models of the real exchange rate have been used as benchmarks. In this case, data constraints limit the choice for what can be used to identify the equilibrium exchange rate. In light of these problems, a much simpler approach is taken, using bilateral PPPs and trade weighting them as the model. While much maligned, PPP remains one of our most durable exchange rate models. A permanent misalignment, therefore, occurs when the value of the exchange rate departs for a sustained period of time from its trade-weighted bilateral PPP value.[15] In line with the theories discussed earlier, one can assume that a sustained undervaluation or overvaluation distorts relative prices in a manner that affects supply and demand determinants of productivity and in a way that feeds in with an appropriate lag on measured productivity outcomes.[16]

The data for the study consist of a panel of annual observations on 18 industries in 14 countries, from 1970 to 1997. All data used in this study were published by the OECD. We obtained industry-specific data from the OECD STAN Database (1998). The STAN Database was constructed to enable international, inter-industry comparisons. The database focuses on manufacturing activities and is organized according to the two- and three-digit International Standard Industrial Classification (ISIC). Our study considers STAN industries at the two-digit level of aggregation. For non-industry-specific data, we use the OECD Monthly Foreign Trade Statistics, Series A, OECD Main Economic Indicators, and OECD National Accounts. The choice of industries was limited by the availability of data, and these industries are listed in the appendix.

2.2 Labour productivity

Labour productivity is calculated on an industry-specific basis—as the real value added in a given industry per number engaged in that industry. Real value-added data are from the STAN database and are PPP adjusted, then divided by the number of engaged to give a real valued per worker definition of average labour productivity. While definition of labour productivity based on hours worked would have been desirable, this was not possible with the STAN data. The "number engaged" includes the number of employees, as well as self-employed, owner-proprietors, and unpaid family workers. Note that this study uses average labour productivity rather than total-factor productivity. This was done because of problems of international comparability in capital stock data and because labour productivity is the focus of interest here.

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[15] This corrects for cases when either all countries are either under- or overvalued vis-à-vis some other currency such as the U.S. dollar, but do not trade much with the United States, or other cases where there may be a lot of bilateral trade (e.g., Britain-Germany), but one country (Germany) is undervalued against the U.S. dollar and the other country (Britain) is not.

[16] This paper does not deal with the feedback mechanism from productivity to long-run equilibrium real exchange rates. Among other things, this would involve correcting the measure of misalignment itself for long-term changes in productivity levels. The cross-sectional variation in the misalignment index is unlikely to be seriously affected by ignoring this factor.

2.2.1 Misalignment index and competitiveness

For each country, i, the misalignment is expressed as:

$$MIS_i = \sum_{n=1}^{N} \omega_{in}\left[\left(\frac{E_i^{nom} - PPP_i}{PPP_i}\right) - \left(\frac{E_n^{nom} - PPP_n}{PPP_n}\right)\right].$$

For countries $i = 1, \ldots, N$, where ω_{in} is country n's share of country i's trade:

$$\omega_{in} = \frac{X_{in} + M_{in}}{\sum_{n=1}^{N} (X_{in} + M_{in})}.$$

Note that misalignment is defined in a relative sense, using OECD PPPs as the benchmark. Thus, even if a country's exchange rate is at the PPP value, if all other countries are undervalued, its index of misalignment will be recorded as an overvaluation or as a positive number. A negative value of the index implies an undervaluation relative to the currencies of a country's trading partners. A positive value implies a relative overvaluation. Finally, the index was adjusted so that, over the entire period, the average misalignment was zero. This was done to reconcile some anomalous cases, probably reflecting price-level-comparison problems, where countries were always over- or undervalued. Figure 3 depicts the misalignment index for the 14 countries. In the case of Canada, the misalignment index increasingly resembles the Canada-U.S. real exchange rate over the past 15 years, because of the growing role of the United States as Canada's largest trading partner. Bilateral trade flows are from the OECD Monthly Statistics of International Trade, Series A. The misalignment indexes suffer from all the usual problems that any PPP-based theory of equilibrium exchange rates does.[17] It would have been desirable to have used industry trade shares to construct industry-specific misalignment indexes. This was not done, however, because trade data are not available on an industry-by-industry basis.

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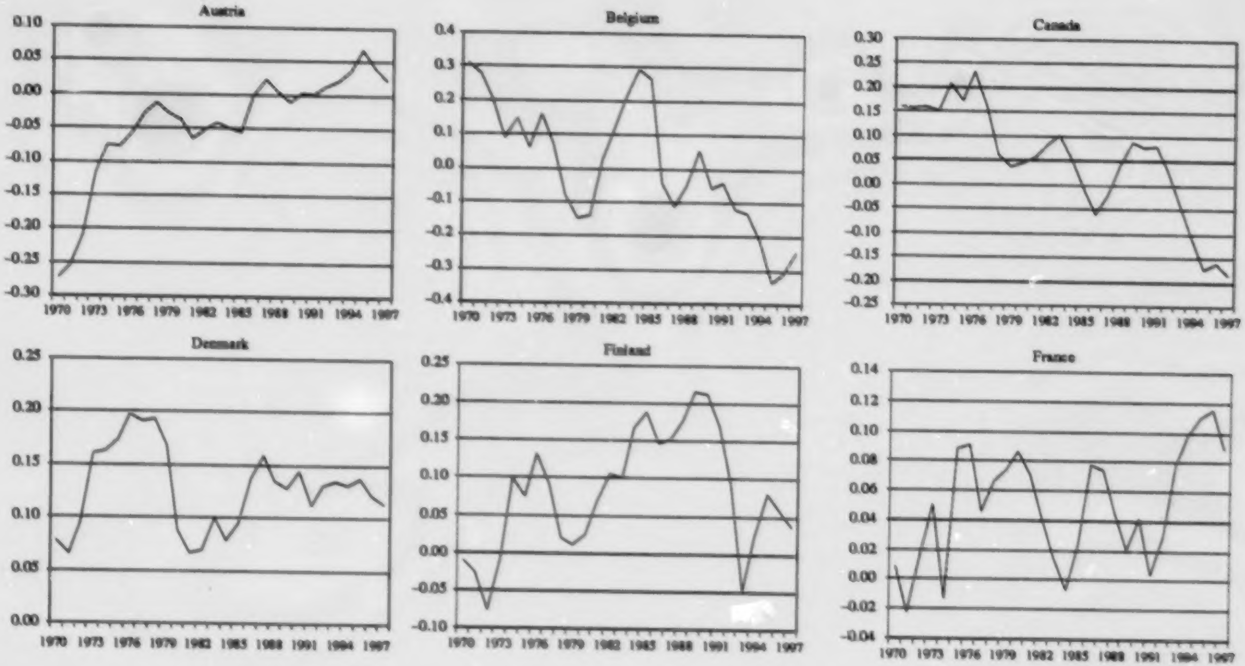
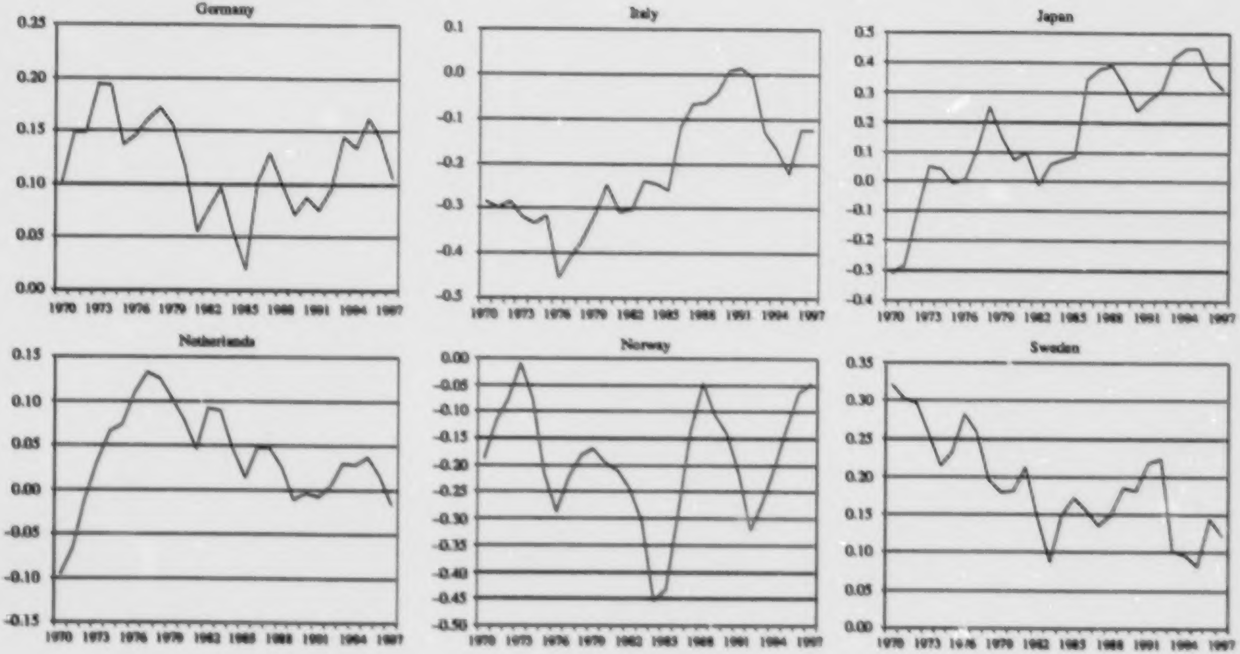
[17] The evidence on PPP is reviewed in Lothian (1997). There is strong evidence that nominal exchange rates converge back to their PPP values, but with substantial lags. It would clearly be desirable to use other indexes of misalignment based on alternative theories of equilibrium exchange rate to check for robustness.

Figure 3
A graphical representation of the misalignment index



(continued)

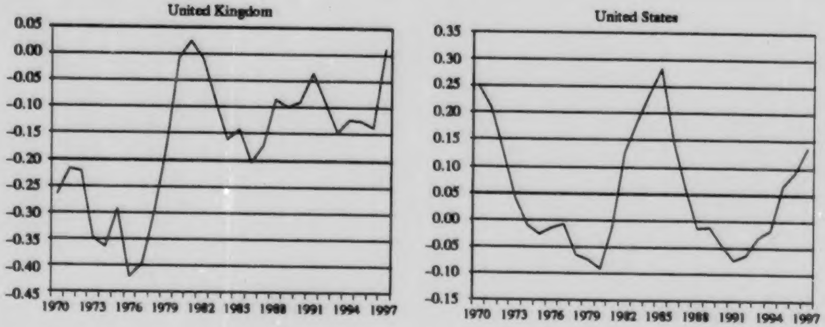
Figure 3 (continued)
A graphical representation of the misalignment index



(continued)

Figure 3 (continued)

A graphical representation of the misalignment index



2.2.2 *Investment-output ratio*

The investment-output ratio is calculated on an industry-by-industry basis. We use STAN data on gross fixed capital formation, adjusted by OECD investment deflators, to represent investment. We GDP-deflate and PPP-adjust STAN value-added data to obtain an industry-specific value-added output measure. Value added is thought to be preferable to gross output, since it (i) is consistent with the productivity numbers used and (ii) eliminates some of the effects of different degrees in outsourcing across different countries in the same industry. The investment variable in the regression model AVIO, is the average of the investment-output ratio over the preceding three periods. This is consistent with other studies of productivity dynamics in which the medium-term impact of past investment is the mechanism by which productivity growth is affected.

2.2.3 *Openness*

Openness is defined on a country basis. Openness (OPEN) is measured on a country-specific, but not industry-specific level. For this paper, openness is defined as the ratio of exports plus imports to squared GDP. This variable is multiplied by 1,000,000 for ease in examining the coefficient. The non-linear openness variable was used rather than an explicit country-size variable. Convergence theory usually predicts that the larger the country, the less significant openness should be as a growth determinant. Given the presence of a number of large countries in the OECD data set, making this correction is important.

2.2.4 *Average productivity*

We include an average-productivity variable to control for convergence or catch-up effects. The average-productivity gap is expressed as the difference between own country, current-period labour productivity, and the average labour productivity obtained in the last period, for a particular industry.

$$AVLPGAP_{ic(t)} = \frac{AVLP_{(i,t-1)} - LP_{ic(t-1)}}{LP_{ic(t-1)}}$$

AVLP refers to the average labour-productivity level across countries. A large positive number for this measure would imply that, for a particular industry, the labour productivity in the country in question was well behind the world average.

2.2.5 Estimation

The following is the basic panel regression model, which is estimated.

$$\Delta A_{ic(t)}/A_{ic(t-1)} = \alpha_{ij} + \beta_1 DMIS_{i(t-1)} + \beta_2 LRMIS_{i(t-1)}$$
$$+ \beta_3 AVIO_{ij(t)} + \beta_4 OPEN_{it} + \beta_5 AVLPGAP_{ij(t-1)} + \mu_{ij}$$

for $i = 1, \ldots, I$ countries and $j = 1, \ldots, J$ industries. All variables in the panel, with the exception of the misalignment index and openness, are industry- and country-specific. The dependent variable is the change in labour productivity over the previous year. The misalignment index is common across industries within any specific country. There are two exchange rate variables: last period's change in misalignment, $DMIS_{t-1}$, and a long-run measure of the level of misalignment, $LRMIS_{t-1}$, which are intended to capture the effect of misalignment in periods $t-1$ and back. This is measured by a linearly declining five-year average of the previous MIS terms, with weights of 5/15 on the first lagged period, declining to 1/15 in the final lagged period.

A positive coefficient on the *DMIS* variables would imply that an exchange rate appreciation would yield positive productivity growth. A positive coefficient on the long-run misalignment index, *LRMIS*, implies that an increase in the degree of overvaluation or a decrease in the degree of undervaluation increases productivity growth. *OPEN* is the openness variable, *AVLPGAP* is the average labour productivity gap of the industry from the world average for that industry, and *AVIO* is the average investment-output ratio defined as gross fixed capital formation divided by value added. The *AVIO* variable is country-industry specific to the two-digit ISIC level. In the estimation, we use an unweighted average of lagged investment-ouput ratio (averaged over lags of –3, –4, and –5) to capture the long-term effects of investment on productivity and to eliminate any problems with simultaneity.

The econometric estimation model is a fixed-effects model that allows the intercept to vary for each industry-country observation. The estimation method is iterative generalized least squares (GLS), using the White heteroscedasticity-consistent variance-covariance matrix. Although the coefficient estimates using pooled least squares were almost identical to the GLS estimates, cross-section weights substantially improved the statistical significance of those estimates. A correction for autocorrelation in the errors was attempted, but there appears to be no evidence of autocorrelation in the errors.

2.2.6 Baseline results

The basic convergence model is reported in Table 4. Both openness and the productivity gap have the expected signs and are significant. A 10 per cent productivity gap relative to the average implies that annual productivity growth is higher by about 1 per cent, than without the gap. One should note that Bernard and Jones (1996) and others found that the convergence effect in the OECD on aggregate manufacturing data was substantially weaker after the mid-1980s. This model is estimated, however, without allowing for a mid-1980s structural break. The average investment-to-output ratio is also positive and significant. The coefficient estimates imply that a permanent 10 per cent increase in the investment ratio corresponds to an increase of annual productivity growth of 1 per cent. This coefficient seems somewhat high, and some literature suggests that it may considerably interact with the openness variable.

2.2.7 Misalignment and exchange rate effects: Results

The results for the misalignment model for a variety of specifications are reported in Table 5 in columns 1 through 3. The competitiveness effect, as measured by the coefficient on *DMIS* is always significant and, as expected, negative. In the first column, for example, which is the basic model, a 1 per cent real depreciation below the equilibrium level of the exchange rate in the previous year would increase labour-productivity growth over the current year by about 0.8 per cent. In contrast, the *LRMIS* variable captures the effect of a sustained misalignment. The positive and significant coefficient on *LRMIS* implies that the empirically estimated effect of an undervalued exchange rate is to reduce productivity growth. The orders of magnitude are illustrated in Figure 4. Here, the model in column 1 is used to simulate the effects of an undervalued exchange rate, which goes from equilibrium level to being 25 per cent undervalued over a two-year period and then stays undervalued. As indicated in Figure 4, the effects on productivity growth are a short but sharp increase in productivity growth, and a subsequent and long-run fall in productivity growth by 0.40 per cent, which persists for about a decade.

Alternative specifications were tried with variations in the way the basic misalignment variable was measured. The conclusions were similar. The model in all cases without investment performs substantially worse than the model with investment. Simultaneity on *LRMIS* and investment requires further investigation. When the model is estimated without fixed effects, it performs substantially worse (Table 5, column 3), and the *LRMIS* variable becomes insignificant. Given the importance of fixed effects in the model, it

Table 4
Baseline productivity model: Estimation results

Dependent variable: Change in labour productivity

Variable	Estimation method = GLS	
	Baseline W/O investment	Baseline W/ investment
AVIO		0.119
		(4.979)
$AVLPGAP_{(t-1)}$	0.103	0.091
	(21.654)	(16.778)
OPEN	–0.008	0.007
	(–5.063)	(5.959)
Sample	1976–96	1976–96
No. of observations	5,849	4,780
R^2	0.173	0.173
Adjusted R^2	0.130	0.130
D-W statistic	1.937	1.915

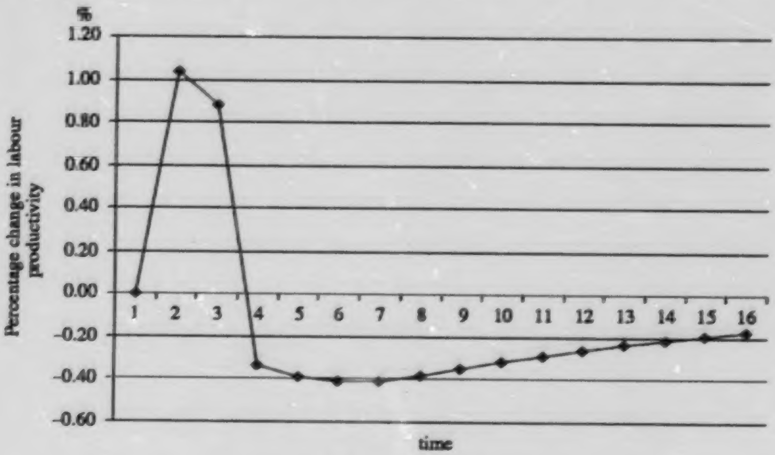
Notes: *t*-statistic in parentheses.

Table 5
Misalignment models estimation results

Variable	Investment	W/O investment	Common intercept (no fixed effects)	Large exchange rate effect model (+/–0.15)
Constant			0.0007	
			(15.206)	
DMIS	–0.083	–0.074	–0.0604	–0.096
	(–8.958)	(–9.571)	(–2.879)	(–10.495)
LRMIS	0.014	–0.001	–0.0096	
	(2.321)	(–0.157)	(–0.709)	
UNDER				–0.002
				(–1.067)
OVER				–0.018
				(–7.962)
AVIO	0.106			0.103
	(4.242)			(4.143)
$AVLPGAP_{(t-1)}$	0.093	0.103	0.0194	0.091
	(17.055)	(21.518)	(4.829)	(16.871)
OPEN	0.043	–0.008	–0.060	0.038
	(5.935)	(0.002)	(–3.313)	(5.281)
Sample	1976–96	1975–95	1975–95	1975–95
No. of observations	4,780	5,849	5,849	4,780
R^2	0.184	0.180	0.020	0.190
Adjusted R^2	0.141	0.138	0.019	0.147
D-W statistic	1.913	1.878	1.959	1.921

Notes: *t*-statistic in parentheses.

Figure 4
Effect of a 25 per cent misalignment on the percentage change in labour productivity



would be desirable to identify other proximate determinants of productivity and to examine how exchange rates influence each of these.

2.2.8 Large exchange rate misalignments

The literature on trade hysteresis produced a number of models and some evidence that changes in trade patterns would occur with "large" exchange rate changes that lasted for a sufficient period.[18] Many of those sorts of arguments might well apply to the type of investments needed to bring about productivity change. For example, it may be the case that many of the supply-side factors are only going to respond to a major exchange rate change, in particular if exchange rate expectations are quite inelastic in the short run. Short-term volatility of exchange rates in a number of models is predicted to reduce the impact of relatively small changes in the rate. To investigate this effect, an alternative index of misalignment is used. The index UNDER is defined as dummy variables, which take the value 1 when the long-term misalignment index, LRMIS, says the exchange rate is under- (or over-) valued by at least 15 per cent or more for at least two years. OVER is defined as an overvaluation of the misalignment index by 15 per cent or more for at least the preceding two years. This model is reported in the last column of Table 5. Both coefficients are significant. The undervaluation coefficient is insignificant although negative. The overvaluation coefficient is negative and significant. It appears that very large overvaluations may lead to lower productivity growth. These results are in contrast with the other misalignment models based on continuous indexes. They also appear somewhat unstable with respect to alternative cut-off values used to define "large" misalignments. There may be some strong non-linear effects here. A severely overvalued exchange rate in levels, for example, may lead to a continuing loss of export markets. These negative effects on output may ultimately swamp any of the productivity-push effects that mildly overvalued exchange rates lead to, which, in turn, would give rise to a highly non-linear effect of LRMIS on productivity growth.

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[18] Harris (1993) op. cit. and Baldwin and Krugman (1989).

2.2.9 *Interaction effects*

The basic model assumes three basic determinants of productivity growth: investment, openness, and the productivity gap relative to the world average. Exchange rate channels on productivity growth may occur by enhancing or diminishing the effect of each of these variables, rather than through an independent effect. The potential for interaction is even greater when one realizes that the three measured "determinants" are proxies for a variety of influences on the unmeasured processes that drive productivity change. For example, one would usually expect the exchange rate effect to be stronger in more open economies, for a number of reasons. Misalignment might enhance the investment effect if a low exchange rate contributes to growth of output in sectors where investment has been high. The "catch-up" effect is generally thought to come through international spillovers of knowledge from high- to low-productivity countries. An exchange rate misalignment might enhance these spillovers if it affects either trade or investment flows through which spillovers are sometimes mediated.

To check for the possible significance of interaction, the model is re-estimated with LRMIS interacted with each of the three variables of the convergence model. These results are reported in Table 6. Three models are reported. The long-term misalignment variable is interacted with openness, investment, and the productivity gap variable, respectively. Of these models, the only one whose performance is not worse and in which the interaction is significant, is that between openness and misalignment. In this case, the exchange rate misalignment variable is highly significant and has a sign that is consistent with the basic thrust of supply-side effects of exchange rate depreciation. For industries that are open to international trade, exchange rate misalignment is more consequential, and in a direction consistent with the long-term, supply-side view of misalignment. The investment-

Table 6
Interaction models estimation results

	Interaction between MIS and openness	Interaction between MIS and investment	Interaction between MIS and convergence
LRMIS*OPEN	0.0287		
	(3.546)		
LRMIS*AVIO		–0.054	
		(–1.479)	
LRMIS* AVLPGAP$_{(t-1)}$			–0.052
			(–1.831)
DMIS	–0.085	–0.091	–0.086
	(–9.229)	(–10.008)	(–9.093)
AVIO	0.115		0.227
	(4.665)		(8.924)
AVLPGAP$_{(t-1)}$	0.092	0.096	
	(16.942)	(17.828)	
OPEN		0.044	0.034
		(6.125)	(4.608)
Sample	1976–1996	1976–1996	1976–1996
No. of observations	4,780	4,780	4,780
R^2	0.181	0.183	0.157
Adjusted R^2	0.139	0.141	0.113
D-W statistic	1.911	1.911	1.966

Notes: *t*-statistic in parentheses.

interaction effect does not appear to work. This may not be too surprising, however. In countries that are exporters of M&E or that are relatively closed, one would not expect the factor-cost effect of an exchange rate change to be very important.

2.2.10 Panel results: Summary

Evidence from the panel model supports the competitiveness view of the positive short-run effects of exchange rate depreciation on productivity and the long-term negative supply consequences of undervalued exchange rates on productivity growth. There is no evidence that a sustained undervalued exchange rate leads to longer-term superior productivity growth. This type of empirical approach forces common parameters across all industries and countries. There is little doubt that this assumption is unjustified and particularly so in the case of the exchange rate variables. Time-series approaches or better structural models may be alternatives. We need more evidence on how differences across countries affect the productivity-exchange rate link.

Conclusions

The results of this paper support the view that real exchange rates affect productivity growth in both the short and long term. In the short run, the results are consistent with the competitiveness hypothesis, which suggests that exchange rate depreciations boost productivity growth in the short run. However, there is also evidence that a sustained real exchange rate depreciation could have negative consequences for long-term productivity growth. Two sorts of evidence are reviewed.

The sustained real depreciation of the Canadian dollar over the 1990s has led to an extensive examination of the long-term productivity consequences of an undervalued exchange rate. The substantial literature on the Canada-U.S. productivity gap points to a number of causal mechanisms in which the Canadian dollar depreciation of the 1990s contributed to factors that worsened the Canadian productivity performance relative to that of the United States. The paper discusses three major productivity channels: (i) the factor-cost effect of a depreciation that raises the cost of imported investment goods; (ii) the impact of a depreciation on innovation and R&D; sustained exchange rate depreciations raise the cost to imported technology and shift profit opportunities where price competition works relative to competition on new or improved product and process innovation. (iii) Exchange rate depreciations can reduce the forces of creative destruction. This can occur in two ways. First, they can affect the exit and entry process in a manner that sustains the existence and growth of small, inefficient firms longer than they would otherwise. Second, during a period of major technological change, capital and labour are sheltered in old slow-growth sectors, and this reduces the rate at which the New Economy high-growth sectors can expand.

To what extent is the Canadian case indicative of a more general link between exchange rates and productivity growth? The second part of the paper looks to international cross-country-industry evidence on productivity dynamics, using a conditional-convergence framework in conjunction with a set of exchange rate misalignment measures. The results are consistent with a model in which, for highly open economies, exchange rate undervaluation carries short-term benefits in productivity growth but long-term costs in productivity performance. The evidence is consistent with theories suggesting that sustained undervaluation appears to lead to deteriorating productivity growth. Whether this will hold up under other approaches and with other data sets should be an important item on the research agenda of both productivity researchers and international economists concerned with the exchange rate as a transmission mechanism in open economies. It also points to the need for further research on the identification of the conditions under which a sustained misalignment is likely to have strong productivity consequences. Productivity effects should be added to the list of criteria and consequences used in the evaluation of flexible versus fixed exchange rate regimes, the cost-benefit analysis of optimal currency areas, and the ex post historical evaluation of sustained real exchange rate misalignments.

Appendix
The Panel

Industry	United States ISIC	Countries
Food, beverages, and tobacco	3,100	Austria
Textiles, apparel, and leather	3,200	Belgium
Wood products and furniture	3,300	Canada
Paper products and printing	3,400	Denmark
Industrial chemicals	3,510	Finland
Other chemicals	3,520	France
Petroleum refineries	3,530	Germany
Petroleum and coal products	3,540	Italy
Rubber products	3,550	Japan
Plastic products	3,560	Netherlands
Non-metallic mineral products	3,600	Norway
Basic metal industries	3,700	Sweden
Metal products	3,810	United Kingdom
Machinery	3,820	United States
Electrical machinery	3,830	
Transport equipment	3,840	
Professional goods	3,850	
Other manufacturing	3,900	

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Discussion

David Longworth

Rick Harris has provided us with a very interesting and timely paper on the relationship between exchange rate movements and productivity changes.

The case of the possibly exchange-rate-induced productivity changes. A case for Hercule Poirot? Perhaps. The dastardly deed is the poorer productivity performance in Canada than in the United States. There are apparently three smoking guns. Evidence is presented that each one of these has something to do with Canada's poorer productivity performance vis-à-vis the United States. The accused is Mr. Depreciation (henceforth, Mr. D.).[1] But did he pull the triggers of the three guns? And to make the case more exciting, new evidence has just come to light: an innovative model of exchange rate misalignment and productivity.

Mr. D. with the three smoking guns? Does he lurk at the Bank of Canada? Rick does not tell us for sure. But wherever he is, he certainly beats out old Colonel Mustard with the candlestick in the conservatory.[2] We're certainly given a lot of clues.

Let's examine each of the smoking guns in turn. As we consider each of them, I will tell you what Mr. D. and I would say, if I were Mr. D.'s defence attorney.

At the outset, it is important to note that, if the movements in the Canadian dollar are largely reflecting fundamentals, as argued in the Djoudad et al. paper in this volume and in the strain of literature starting with Amano and van Norden (1993), it is the fundamentals that are leading to any of the effects argued for by Harris, and not Mr. D. at all.[3]

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[1] It is never entirely clear whether Mr. D. has "Nominal" or "Real" for his first name. The references to the exchange rate regime suggest "Nominal," but most of the arguments and empirical work relate to "Real." Below, I concentrate mostly on "Real."

[2] With apologies to the creators of *Clue*™.

First, the "relative factor-cost" gun. The Canadian rental-wage ratio has risen 30 per cent in Canada relative to that in the United States from 1991 to 1999. This is blamed on Mr. D. If I were Mr. D.'s defence attorney, I would first note that this rise was largely a reversal of the decline in the 1986–91 period (Figure 2 in Harris's paper) that was associated with rising changes in Canadian unit labour costs and a real appreciation of the Canadian dollar. I would also grill the expert witness on how these aggregate data were constructed:

- Do they now include software in the United States (but not in Canada)?
- Does Statistics Canada assume the law of one price between Canada and the United States in constructing the data on the price of investment in computer equipment? (There is a lot of anecdotal evidence that, at least for personal computers and personal computer software, there is significant pricing to market.)

Second, the "innovation-gap" gun. This gun is evidently smoking quite a lot. It is not clear, however, whether Mr. D. was ever holding it. Pricing-to-market issues are at play for technology transfers as well as for investment. And Mr. D. would like to know for which period of time he is charged with the offence. Most of the data in the "court documents" are for the period ending in 1995 or 1996, a period over which there is little or no evidence of a significant brain drain.[4] It is only over the last two or three years, if at all, that the case can be made for the significance of this drain.

Third, the "slowdown in creative destruction" gun. Mr. D. protests that an increase in creative destruction did not seem to be required in the United States (at least after 1990–92). Indeed, the argument made for productivity gains in the United States has been exactly the opposite—the United States has been pushing against capacity limits, especially in the last five years or so, which has led to at least part of the productivity gains. Canada experienced a large real exchange rate appreciation through November 1991, but the creative destruction of that period did not seem to be helpful in increasing productivity. Indeed, some argued vehemently at the time that a real exchange rate appreciation was exactly the worst thing to have if one wanted to take advantage of the free trade agreement with the United States.

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[3] Moreover, if fundamentals are driving movements in the real exchange rate, it is difficult to see how changing the exchange rate regime would change the fundamentals and the real exchange rate movements.

[4] See, for example, Helliwell (1999) and Human Resources Development Canada and Statistics Canada (1999).

Mr. D., when called to the stand, would also argue that increases in cash flow (which are probably negatively correlated with creative destruction) tend to promote investment.[5] Furthermore, the ratio of investment in machinery and equipment to GDP has picked up substantially in Canada in the last few years despite the low value of the Canadian dollar. Rising investment is exactly what most experts think is one of the major factors increasing productivity (based on regressions such as those reported in Tables 4 and 5 of Harris's paper).

Is the new evidence that has come to light the one thing that will really convince the jury? I think that the jury will be confused.

The equations estimated in the "court documents" are of the following type: the percentage change in labour productivity (*DLP*) in a given industry and country is a function of the change in real exchange rate misalignment (*DMIS*), a weighted moving average over five years of past exchange rate misalignments (*LRMIS*), several other explanatory variables (including investment in some equations but not others), and a term that captures the percentage difference between the average level of labour productivity across countries for a particular industry and the lagged level of labour productivity domestically in that industry.

A feature of the estimated specifications is that a misalignment arising from a real depreciation initially causes a rise in productivity. In specifications that include investment (e.g., the first column in Table 5 and the first column in Table 6), the coefficient of the past misalignment variable (*LRMIS*) indicates that a permanent real depreciation eventually leads to a permanent decline in productivity. On the other hand, in specifications that exclude investment, the coefficient of the past misalignment variable is of the opposite sign, indicating that a depreciation never leads to a decline in productivity. One plausible explanation for the differences in these results is that a depreciation, through its effect on net exports, could increase cash flow and/or expected future output, therefore having a tendency to increase investment. The specifications with investment would capture this effect through the investment variable, while the other specifications would capture this effect directly through the misalignment variable.

In any event, it is important to note that the lags between misalignment and the *level* of productivity are very long, with it taking at least eight years (in the case of the simulation in Figure 4, which is based on an equation with investment and with investment treated exogenously) for productivity to fall below its initial level.

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[5] Because of asymmetric information, the cost of internal funds is likely lower than the cost of external funds.

As well, and perhaps most importantly, the specification with the highest adjusted R^2 has a significant negative effect of overvaluations on productivity, but no statistically significant effect of undervaluations on productivity (final column in Table 5).

Stepping out of my role as Mr. D.'s attorney, I now ask, "Who done it?"

First, it obviously has been "done." On average, over the last ten years, productivity performance in Canada has not been as good as it has in the United States.

Second, all three guns exist, but perhaps only the second one is smoking.

Third, it is not obvious that Mr. Depreciation, on his own, squeezed any of the triggers.

Fourth, given the differing stories across equations, the prosecution will have difficulty using its new evidence to convince the jury.

Fifth, three or four years from now, one might never think of charging Mr. D. There are some encouraging signs that productivity may be picking up, including the rise in the ratio of investment in machinery and equipment to GDP. It's too early to say for sure—and a central bank should not count on it—but it is too soon for other policy-makers to panic.

More importantly, putting Mr. D. on trial cannot be used as a way to determine whether the nominal exchange rate regime is guilty of reducing productivity growth. To convict the exchange rate regime, one has to show beyond a shadow of a doubt that the major movements in real exchange rates were not related to real fundamentals.

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General Discussion

David Laidler opened the discussion by asking whether the real depreciation that occurred in the 1990s could have been prevented by stabilizing the nominal exchange rate. He also questioned the use of purchasing-power parity (PPP) to determine the equilibrium exchange rate.

Richard Harris replied that PPP provides the best available approximation for the equilibrium real exchange rate for a wide range of countries.

Andrew Rose touched on the literature that seeks to link productivity to exchange rate regimes and, in particular, on his and Frankel's unsuccessful efforts to find such a link.

Eduard Hochreiter described the efforts of Austrian policy-makers in the 1970s to lower inflation and increase productivity. They adopted an appreciated value for the schilling relative to the German mark to encourage productivity growth, and this measure was accepted by the unions, who recognized it as a means to obtaining higher real wages. At the same time, Austria adopted supply-side measures to encourage investment. Since then, it has experienced higher productivity growth then Germany, but also more inflation.

Robert Lafrance noted that it is difficult to make productivity growth rate comparisons with the United States over short sample periods. Hence, it may be misleading to attribute Canada's recent productivity performance to a depreciating nominal exchange rate.

Session 5: Implications for Emerging-Market Economies

Exchange Rate Regimes and Economic Growth in Emerging Markets

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Jeannine Bailliu, Robert Lafrance,
*and Jean-François Perrault**

Introduction

The choice of exchange rate regimes in emerging-market economies has generated ongoing interest in the field of economics. This discussion has been rekindled in recent years as a result of a series of economic crises in emerging markets (such as Mexico, Southeast Asia, Russia, and Brazil) in which unsustainable exchange rate regimes were widely perceived to have been a determinant of these crises. As a result, the adequacy of exchange rate arrangements is one of the key issues being discussed in international forums, such as the International Monetary Fund (IMF), the G-7, and the G-20. One aspect of this debate is the notion that in a world of increasing international capital mobility, only polar regimes (i.e., hard pegs—such as currency boards and monetary unions—or floating exchange rate regimes) are likely to be sustainable.[1] This proposition, however, is fairly controversial. Indeed, some believe that intermediate regimes are, and will continue to be, a viable option for emerging markets (for example, see Williamson 2000).

An important question that arises in this debate is whether the nature of the exchange rate regime influences economic performance. While previous research in this area has focused on the possible effect of exchange rate

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[1] Eichengreen (1998) and Obstfeld and Rogoff (1995), among others, have made this point.

* We would like to thank Larry Schembri and Kevin Clinton for providing comments. We have also benefited from discussions with many of our colleagues in the International Department at the Bank of Canada.

regimes on inflation performance and output variability, this paper examines whether the choice of regime can affect a country's growth performance.[2]

Economic theory suggests that the nature of the regime should not affect the long-run equilibrium value of real variables, but that it can influence the adjustment process.[3] One would expect, therefore, that the real exchange rate would eventually return to its long-run equilibrium following an economic shock, regardless of the nature of the regime. The transitional dynamics, however, can vary for different types of regimes. With the price rigidities in the goods and labour markets, for instance, one might expect a smoother transition to the new equilibrium under a more flexible exchange rate regime. A more flexible arrangement is also less likely to generate persistent misalignments in exchange markets, which may result in an economic crisis. On the other hand, many believe that flexible exchange rates are inherently volatile and prone to misalignments.[4] Thus, exchange rate shocks, which are more closely identified with flexible regimes, could affect resource allocation decisions. Furthermore, countries with underdeveloped or weak financial systems are also likely to have problems accommodating large exchange rate movements under flexible regimes. Consequently, the type of exchange rate regime could influence an economy's growth performance through its effects on the adjustment process.

The objective of our paper is to investigate empirically the implications of the exchange rate regime for economic growth. Previous empirical work in this area has failed to identify a robust relationship between the choice of the exchange rate regime and growth. Several authors, including Calvo and Reinhart (2000), have noted that this could be the result of measurement error in the classification of exchange rate arrangements. Most studies are based on the IMF's official exchange rate classification, which is based on self-classification by member countries. In most studies, however, no effort is made to ensure that this de jure classification is consistent with actual practice. Our study addresses this issue by using two different classification schemes: the official designation and a classification based, in part, on the observed degree of exchange rate flexibility.

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[2] See Edwards and Savastano (1999) for a review of this literature, which comprises both individual- and multi-country studies.

[3] For instance, Helpman (1981) and Lucas (1982) have shown—in models with perfect foresight—that the nature of the regime does not affect the long-run equilibrium allocation of resources. Others, such as Mundell (1968), have emphasized that, even though the long-run equilibrium is the same, the adjustment process towards the equilibrium will be different in fixed and flexible regimes.

[4] Baxter and Stockman (1989) and Flood and Rose (1995) provide evidence of heightened exchange rate volatility after the collapse of the Bretton Woods regime. Caporale and Pittis (1995) show that the nature of the regime can affect the persistence of economic shocks.

Our paper also differs from existing work in that we investigate the effect of the exchange rate regime on *medium-term* growth, averaging the data over a five-year period, as opposed to using annual data, as do Ghosh et al. (1997).[5] Using five-year periods is typical in the empirical-growth literature, since this interval is thought to be long enough to eliminate business cycle effects, but short enough to capture important changes that occur over time for a particular country. Another distinguishing feature of our study is that we consider the possibility that the effect of the exchange rate regime on growth may depend on a country's degree of openness to international trade and capital flows and on its level of financial sector development.

We estimate the impact of the type of exchange rate regime on growth using a panel-data set of 25 emerging-market economies over the 1973–98 period in a framework that controls for other determinants of growth, while accounting for country-specific effects and for the presence of global shocks. We find evidence that more flexible exchange rate arrangements are associated with higher economic growth, but only for countries that are relatively open to international capital flows and, to a lesser extent, that have well-developed financial markets. While we originally found a similar result with respect to international trade, this evidence was not robust to the presence of a few outliers. Finally, our results also suggest that a change in the exchange rate regime is associated with lower economic growth.

Our paper is organized as follows. Section 1 reviews the key theoretical arguments that motivate our empirical investigation. In section 2, we outline our exchange rate regime classification schemes. The empirical methodology is described in section 3, and the estimation results are presented in section 4. Conclusions follow.

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[5] Ghosh et al. (1997) produced the only other cross-country study that, to our knowledge, has examined the potential implications of exchange rate regimes for growth in an econometric framework that controls for other determinants of growth. Their study, using data on 136 countries over the period from 1960 to 1989, finds no systematic differences in growth rates across exchange rate regimes. The IMF (1997) found a similar result when extending the period of analysis to the mid-1990s. The latter study, however, does not control for other determinants of growth.

1 Exchange Rate Regimes and Economic Growth

Although economic theory suggests that the type of exchange rate arrangement may matter for growth, it does not clearly ascertain what type of arrangement would be more likely to promote growth. The theoretical literature on the subject is quite thin and usually derived from studies that are *indirectly* linked to growth, such as export growth or currency crises. Our review of the literature, therefore, is selective and directed at the hypotheses that we wish to test. We consider four hypotheses on how the exchange rate regime could accept growth.

First, we test whether the degree of flexibility of the exchange rate regime influences economic growth. Theory does provide some guidance on how different exchange rate arrangements could influence growth, but it does not yield a clear-cut prediction in terms of whether a flexible regime would be more likely to promote higher growth. It has been argued that a more flexible arrangement may foster growth, since it will enable an economy characterized by nominal rigidities to absorb and adapt to economic shocks more easily, because exchange rate movements can act as shock absorbers. A flexible exchange rate also allows a country to have an independent monetary policy, providing the economy with another means to accommodate domestic and foreign shocks. When the adjustment to shocks is smoother, one would expect productivity growth to be higher, given that the economy is, on average, operating closer to capacity.

Some would contend, however, that a more flexible regime is more prone to exchange rate shocks, which might dampen growth. The point has also been made that many emerging-market economies have not benefited from an independent monetary policy because of poor macroeconomic policy management, and that they are better off fixing their exchange rate to a hard currency. Our first hypothesis, therefore, is that the nature of the exchange rate regime influences economic growth, although it is unclear, a priori, whether a more or less flexible arrangement will tend to be associated with higher growth.[6]

Second, we test for evidence that a change in regime is associated with lower economic growth. As discussed in Masson (2000), countries frequently alter their exchange rate arrangements, voluntarily or otherwise. When a country is forced to abandon its exchange rate regime because it has become unsustainable, a costly crisis can ensue. The 1990s witnessed many such episodes with countries on fixed, but adjustable, exchange rate arrangements. Some economists, notably Obstfeld and Rogoff (1995), have argued that these regimes have a limited chance of survival in a world of integrated capital markets and that they will eventually break down.[7]

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[6] Properly stated, our null hypothesis is that the exchange rate regime has *no* effect on economic growth, since we test for its effect on growth by examining whether the coefficient on the exchange rate regime variable is statistically different from zero. The same applies to the other three hypotheses that we test.

Pegged exchange rates are a form of implicit guarantee and can, therefore, be a source of moral hazard. As such, they may promote unhedged foreign currency borrowing and encourage less than prudent foreign currency exposure by domestic financial intermediaries or non-financial corporations. The main cost of pegged exchange rate regimes follows from their periodic breakdowns.[8] These costs greatly exceed estimates of direct costs of misalignments under either regime, particularly when the currency crisis is associated with a banking crisis.[9] Consequently, the second hypothesis that we test is whether a change in regime is linked to lower economic growth, since such a change is often associated with a costly crisis.[10]

Third, the degree of openness of the economy to international markets, in conjunction with the nature of the exchange rate regime, could affect a country's growth. We test whether the effect of the regime on growth will be more pronounced in countries that are relatively more open to international trade and capital flows. The endogenous-growth literature has established a positive link between openness to international trade and economic growth, since countries that are more open to international trade will tend to grow more rapidly, because they have developed a greater ability to absorb technological advances and can take advantage of larger markets (Edwards 1993; Barro and Sala-i-Martin 1995). Although the link between international trade and growth has received more attention in the growth literature, openness to international capital flows can also be an important engine of growth. As emphasized by Bailliu (2000), international capital flows can promote growth by increasing the domestic investment rate, by leading to investments associated with positive spillovers, and/or by increasing domestic financial intermediation. Thus, to the extent that the nature of the exchange rate regime influences the volume of international trade and capital flows, this could translate into an effect on growth.

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[7] They note that the number of long-lived fixed exchange rate regimes still remaining in the mid-1990s was rather small. Apart from very small open economies, only six important countries had maintained a fixed exchange rate for five years or more: Austria, Hong Kong, Luxembourg, the Netherlands, Saudi Arabia, and Thailand.

[8] The link between regimes and currency crashes is not clear-cut. An IMF survey paper notes that of the 116 currency crashes (defined as having a depreciation of at least 25 per cent and a 10 per cent increase in the rate of depreciation over the previous year) that took place between 1975 and 1996, close to half were under flexible regimes (IMF 1997, 91). However, this somewhat counterintuitive observation could also reflect the fact that many exchange rate regimes might have been improperly classified as flexible when they were, in fact, pegged regimes.

[9] By one estimate, for instance, the public sector bailout costs of resolving banking crises in developing countries over the 1980–95 period have amounted to around US $250 billion (Honohan 1997). In more than a dozen of these cases, the public sector resolution costs amounted to 10 per cent or more of the country's GDP and exceeded this level for the main countries affected by the Asian financial crisis (Goldstein, Kaminsky, and Reinhart 2000, 2). The costs of currency crises have also been significant. Goldstein, Kaminsky, and Reinhart (2000, 88) found that it can take between two and three years for economic growth to return to its pre-crisis average.

[10] We are not making any assumptions about causality here. Indeed, it is not unreasonable to expect that a change in regime could precede an economic crisis.

The literature suggests that international trade is influenced by the type of exchange rate arrangement, but does not clearly predict which regime is more likely to foster international trade. It has been suggested that trade should be higher under fixed arrangements, since exchange rate volatility and uncertainty will be lower, which will tend to reduce the cost of trade and, hence, increase its volume.[11] But it has also been argued that flexible regimes are more supportive of export growth, because they are less likely to create conditions for persistent misalignments.[12] Regardless of the degree of flexibility of the regime, however, the effects of the exchange rate arrangement on growth through the trade channel are likely to be more pronounced for countries that are more open to international trade. Therefore, we test whether the effect of the exchange rate regime on growth is influenced by a country's degree of openness to international trade.

A similar hypothesis is tested for the link between exchange rate regimes, openness to international capital markets, and growth. We explore the notion that the benefits of international capital flows for growth might be more pronounced for a country with a more flexible exchange rate arrangement. Capital flows could be more likely to promote growth under a flexible regime, because a more fixed arrangement can be associated with an increase in speculative capital flows. Indeed, it has been argued that capital flows to emerging markets in the 1990s were often encouraged by implicit government guarantees, such as a fixed or quasi-fixed exchange rate

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11. Rose (2000) found evidence that currency unions have a positive effect on international trade, and that exchange rate volatility exerts a negative influence. Frankel (1997) has argued that fixed exchange rates promote trade growth, notably in currency unions.

12. Nilsson and Nilsson (2000), using a gravity model and export flows for more than 100 countries, found that more flexible regimes favour export growth and, by implication, output growth.

regime.[13] Capital flows occurring in this context are less likely to foster growth if they are channelled into unproductive investments.[14]

Finally, we test the hypothesis that a country must have fairly well-developed financial markets to benefit from a flexible exchange rate arrangement. Flexible arrangements are generally associated with increased nominal exchange rate volatility, which, in turn, can dampen growth by reducing investment and international trade. Thus, a country is likely to perform better under a flexible regime if it has a reasonably well-developed domestic financial system with the ability to absorb exchange rate shocks and with appropriate instruments to hedge against exchange rate volatility. Aizenman and Hausmann (2000) note that most emerging-market economies have shallow capital markets. Producers rely mostly on domestic credit to finance their capital needs, since the local market is often segmented from the international market owing to country-specific risks. In the model that they develop to reflect these stylized facts, greater exchange rate stability lowers interest rates (i.e., risk premiums), thereby increasing output. However, greater access to global capital markets reduces the real interest rate benefits from exchange rate stability and increases the optimal flexibility of exchange rates. Aizenman and Hausmann suggest that the gains from fixing the exchange rate may be greater for emerging-market economies than for OECD countries.

Although the effects of financial sector development on growth might be more pronounced for countries with more flexible exchange rate arrangements, a sound and well-developed financial sector is important for growth, regardless of the type of arrangement. A large body of work, reviewed by Levine (1997), has shown how the existing level of development of the financial system—reflected in its ability to exercise functions such as mobilizing savings, helping to allocate capital, and facilitating risk management—can promote growth through its effects on capital accumulation.[15] In addition, empirical evidence supports the view that a well-functioning financial system contributes to economic growth.[16] Empirical studies of the contribution of financial systems and financial development to GDP per capita growth generally find a positive association (Goldsmith 1969; King and Levine 1993).

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[13] Dooley (1994), among others, has made this point.

[14] For example, Krugman (1998) and Corsetti, Pesenti, and Roubini (1998) develop models where foreign creditors believe they will be bailed out by the government and, hence, lend to local banks, which then channel these capital flows into largely unproductive investments. The banks have an incentive to engage in *excessive* risky lending, because their liabilities are implicitly guaranteed by the government. (They are also poorly regulated.)

[15] A more developed financial system can promote growth by increasing the efficiency with which savings are allocated to investment and/or by improving the allocation of capital.

A banking crisis is more likely to occur under a fixed exchange rate regime, particularly if the banking sector is underdeveloped and poorly regulated. Chang and Velasco (2000) argue that a hard peg makes balance-of-payment crises less likely only by making banking crises more likely. In contrast, a flexible exchange rate arrangement may help avoid a crisis, provided that bank deposits are denominated in domestic currency and that the central bank stands ready to act as lender of last resort. Caballero and Krishnamurthy (1999) show that weak financial links, when combined with underdeveloped domestic financial markets, can account for the chief features of recent financial crises.[17]

2 Exchange Rate Regime Classification

As noted earlier, few studies have been able to identify a robust relationship between economic activity and the nature of the exchange regime. Several authors note that this could be the result of measurement error in the classification of exchange rate arrangements. We propose to augment our empirical analysis with an alternative exchange rate classification scheme that seeks to more accurately reflect the degree of exchange rate flexibility.

The IMF's official exchange rate classification is based on self-identification by member countries.[18] No effort is made to ensure that this de jure classification is consistent with actual practice. It is possible, therefore, to identify instances in which actual regimes differ from the stated arrangements. Levy Yeyati and Sturzenegger (1999) find that of the 35 countries identified in 1998 as free floats, 12 (all of them emerging-market countries) could not, in fact, be considered floaters. Calvo and Reinhart (2000) conclude, more forcefully, that most countries identifying themselves as floaters actually follow more rigid exchange rate arrangements. They dub this phenomenon "fear of floating." The conclusion that countries have through time moved from fixed to more flexible arrangements, is thus debatable, and this clearly has implications for empirical analysis.

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[16] Causality in this case is not unidirectional, however. Economic activity and technological innovation affect the structure and quality of financial systems. Moreover, as Levine (1997) points out, other factors, such as a country's legal system and political institutions, drive both financial and economic development at critical junctures in the growth process.

[17] Firms in economies with underdeveloped financial markets—denoting a scarcity of domestic collateral in their model—systematically underestimate the social value of their access to international capital markets. As a result, these economies arrive in downturns unprepared, and they experience costly crises. In addition, a fall in asset prices can compromise the banks' balance sheets and result in a domestic credit crunch.

[18] The IMF publishes this classification annually in its *Annual Report on Exchange Arrangements and Exchange Restrictions*.

The literature on de facto exchange rate classifications is slowly developing. The most important contributions have been those of Levy Yeyati and Sturzenegger and Calvo and Reinhart. These studies focus on the relationship between exchange rate regimes and volatility of the exchange rate and international reserves. In theory, more flexible arrangements should exhibit greater nominal exchange rate volatility and lower international reserve volatility for given terms-of-trade shocks than would more rigid arrangements. Using cluster analysis, Levy Yeyati and Sturzenegger find that 26 per cent of the countries examined follow an exchange rate arrangement that is different from their de jure regime. The majority of these cases were concentrated in emerging markets. Calvo and Reinhart, using more traditional economic analysis and accounting for movements in commodity prices, arrive at a similar conclusion.

Using exchange rate and international reserve volatility as conditioning information for a de facto classification of exchange rate arrangements is a promising avenue. There are, however, two main drawbacks to such an approach. First, as noted by Panizza, Stein, and Hausmann (2000), external shocks can lead to errors in interpreting the true nature of the regime. Large shocks might lead to sharp revaluations of pegged currencies, while floating currencies experiencing limited external shocks might exhibit little volatility. The importance of external shocks in the determination of exchange rate volatility is noted by Calvo and Reinhart. Second, it is not apparent how one can control (apart from through direct observation) for the higher volatility that is associated with fixed regimes undergoing revaluations.[19]

We propose a two-step hybrid mechanical rule (HMR) that classifies exchange rate regimes in terms of their observed flexibility and that takes into account external shocks and revaluations. We adopt the tripartite official classification of Ghosh et al. (1997), in which regimes are classified as fixed, intermediate, or flexible.[20]

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19. Panizza, Stein, and Hausmann propose an interesting indicator of the degree to which countries intervene in foreign exchange markets. It is defined as the ratio of the standard deviation of monthly percentage changes in the nominal exchange rate to the standard deviation of international reserves/M2 for a given year. This methodology, however, is subject to the caveats identified in the text.

20. Single currency and basket pegs are classified as fixed exchange rate regimes. Intermediate regimes include unclassified floats and floats within a predetermined range. Flexible arrangements include those that allow the currency to float without a predetermined range and those that are pure floats.

Our algorithm is based on observed nominal exchange rate volatility, as well as the official classification.[21] In the first step, we classify countries that describe themselves as fixed regimes, since the literature has identified a bias for declaring exchange rate arrangements as being more flexible than they actually are. This rule reduces the probability of identifying currency revaluations in fixed regimes (which induce significant volatility) as representing flexible regimes. We classify as fixed all regimes in which exchange rate volatility is less than 0.45 percentage points over a given year. This threshold, while arbitrary, is broadly consistent with the IMF's survey: most de jure fixed arrangements in our sample show exchange rate volatility of less than 0.45 percentage points. This scheme allows us to classify the following arrangements as fixed: currency boards, straight pegs, crawling pegs, and narrow trading bands.

Identifying intermediate and flexible regimes is based entirely on observed exchange rate volatility. To control for external shocks, which we assume are principally related to terms-of-trade shocks, we group the countries in our sample into regional blocks. We then develop an exchange rate flexibility index based on the degree of exchange rate volatility relative to the regional average for each year of our sample period. Countries whose flexibility index is greater than 1 are considered flexible; the others fall into the intermediate category.

Using the regional average exchange rate volatility as a proxy for terms-of-trade shocks assumes a broad conformity of regional trade patterns. We believe that this is a reasonable assumption, since the countries in the identified regions share characteristics and may often be subject to common shocks, at least to a degree sufficient for the approach to have some merit.[22]

Not surprisingly, the HMR identifies fewer flexible exchange rate arrangements than the official classification. Over 50 per cent of the countries identifying themselves as floaters are found to follow more rigid arrangements (see Table 1), and the HMR shows no generalized movement towards floating regimes (Figure 1). It also points to a more generalized adoption of intermediate regimes, in line with the recent literature on de

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[21] We measure exchange rate volatility by the standard deviation of monthly percentage changes in nominal U.S. dollar exchange rates over a given year.

[22] An additional caveat should be mentioned. By construction, this method will always identify some regimes as intermediate and flexible. It might, therefore, be more appropriate to view our rule not as a substitute for the official classification, but as a method of ordering regimes by their degree of flexibility.

Table 1

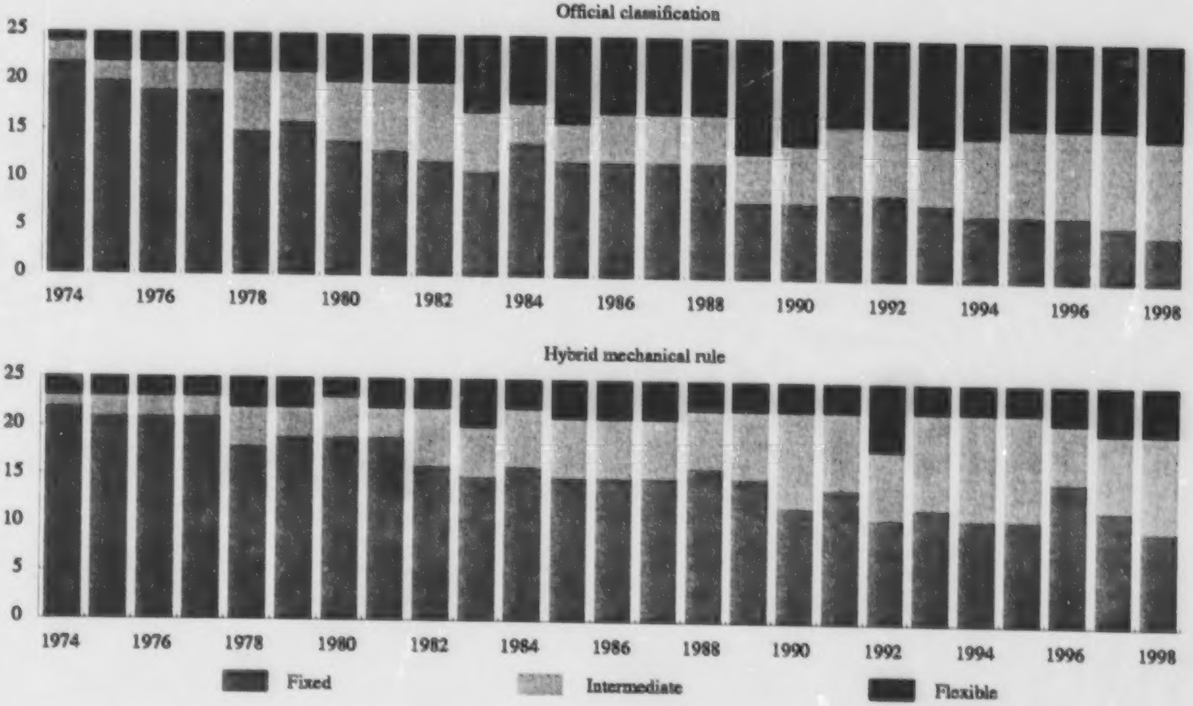
Classification of exchange rate arrangements

	1973–77		1978–82		1983–87		1988–92		1993–97	
	Official	HMR	Official	HMR	Official	HMR	Official	HMR	Official	HMR
Argentina	Fix	Fix	Flex	Flex	Flex	Flex	Flex	Flex	Fix	Fix
Bolivia	Fix	Fix	Fix	Fix	Fix	Fix	Int	Fix	Int	Fix
Brazil	Fix	Fix	Int	Int	Int	Flex	Int	Flex	Int	Int
Chile	Fix	Fix	Fix	Fix	Int	Int	Int	Int	Int	Int
China	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix
Colombia	Int	Fix	Int	Fix	Int	Fix	Int	Fix	Int	Int
Costa Rica	Fix	Fix	Fix	Fix	Flex	Int	Flex	Int	Flex	Fix
Ecuador	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Int	Int
El Salvador	Fix	Fix	Fix	Fix	Fix	Fix	Flex	Fix	Fix	Fix
Guatemala	Fix	Fix	Fix	Fix	Fix	Fix	Int	Int	Flex	Int
Guyana	Fix	Fix	Int	Fix	Fix	Fix	Fix	Fix	Flex	Int
Honduras	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Int	Int
Hong Kong	Flex	Int	Flex	Flex	Fix	Fix	Fix	Fix	Fix	Fix
Indonesia	Fix	Fix	Int	Fix	Int	Int	Int	Fix	Int	Fix
Korea	Fix	Fix	Flex	Fix	Flex	Int	Flex	Int	Flex	Int
Malaysia	Flex	Flex	Flex	Int	Flex	Int	Flex	Int	Flex	Flex
Mexico	Fix	Fix	Int	Fix	Flex	Int	Int	Fix	Flex	Flex
Nicaragua	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Int	Fix
Panama	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix
Paraguay	Fix	Fix	Fix	Fix	Fix	Fix	Flex	Int	Flex	Fix
Philippines	Flex	Int	Flex	Fix	Flex	Flex	Flex	Int	Flex	Int
Singapore	Fix	Fix	Fix	Fix	Fix	Fix	Flex	Flex	Flex	Int
Thailand	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix	Fix
Uruguay	Int	Int	Int	Int	Flex	Int	Flex	Int	Int	Int
Venezuela	Fix	Fix	Fix	Fix	Fix	Fix	Flex	Int	Int	Fix

Note: Shaded areas represent periods during which official and mechanical classification differ.

Fix: fixed; Flex: flexible; Int.: intermediate.

Figure 1
Exchange rate arrangements by classification



facto exchange rate arrangements.[23] Exchange rate regimes tend to be less flexible than advertised for the Asian countries in our sample. In Korea, for instance, we find that, since 1978, the regime has been less flexible than officially stated. As of 1988, Indonesia's exchange rate regime could, for all intents and purposes, be classified by the HMR as a fixed arrangement, even though the regime was officially classified as intermediate. In Latin America, with the exception of Colombia and Costa Rica, there is less systematic divergence between the HMR and the official classification. Note that the HMR finds significantly less flexible exchange rates for Mexico in the period leading up to the peso crisis than the official classification would indicate.

3 Empirical Methodology

This study estimates a cross-country growth regression on a panel-data set of 25 emerging-market countries over the 1973–98 period to investigate whether the nature of the exchange rate regime has an effect on economic growth.[24] This section describes the econometric specification used and then discusses the expected signs on the coefficients of the explanatory variables.

The following equation describes the general specification used:

$$GR_{i,t} = \alpha_i + \eta_t + V_{i,t}\beta + X_{i,t}\delta + \varepsilon_{i,t}, \tag{1}$$

where $GR_{i,t}$ is the growth rate of real per capita GDP in country i and time period t, α_i is a country-specific effect, η_t is a time dummy, $V_{i,t}$ is a row vector of growth determinants measured at the beginning of period t, $X_{i,t}$ is a row vector of growth determinants measured as averages over period t, and $\varepsilon_{i,t}$ is an error term. As mentioned, five-year periods are used.

The country-specific effect, α_i, is designed to capture the determinants of a country's growth rate that are not already controlled for by the other explanatory variables. It thus accounts for unobservable characteristics that vary across countries but not over time. The country-specific effect could be either a *fixed* effect (i.e., a constant that varies for each cross-sectional unit), or a *random* effect (i.e., a random variable drawn from a common distribution with mean α and variance σ_α^2). We use a Hausmann test to decide whether it is more appropriate to model the country effects as being fixed or random.[25] The time dummy, η_t, is intended to capture the effects of global shocks—such as the oil shocks of the 1970s or the debt crisis of the 1980s—on economic growth.

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[23] This result is in line with Masson's (2000) finding that an intermediate exchange rate regime is not a "vanishing" state. He concludes that the intermediate cases are likely to continue to constitute a sizable portion of actual exchange rate regimes.

[24] The cross-country growth regression is the econometric specification typically used in the empirical literature that studies the determinants of growth rates across countries. It is based on work by Kormendi and Meguire (1985) and Barro (1991).

In addition to accounting for country-specific effects and the presence of global shocks, it is also important to control for other determinants of the growth rate to ensure that the estimated coefficient captures the effect of the exchange rate regime on growth and not the influence of some other variable(s). The literature guided us in selecting appropriate control variables.[26]

Two of the variables are measured at the beginning of each period, and they represent initial conditions in a neo-classical growth model. The first is per capita income (in natural log form). According to neo-classical theory, the coefficient on per capita income represents the convergence effect and should be negative.[27] In endogenous-growth models, there is no convergence effect, since economies do not depart from their steady states, and therefore the coefficient is expected to be zero. The second variable is a measure of the stock of human capital.[28] Growth theory, whether neo-classical or endogenous, predicts that the coefficient on the stock of human capital should be positive, since countries that have more human capital will tend to have higher growth rates.

The other control variables are measured as averages over each five-year period and include the real investment rate, the real share of government consumption, measures of openness to both international trade and international capital flows, and a measure of financial sector development.[29] The expected sign on the investment rate is positive, since capital

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[25] The null hypothesis of the Hausmann test in this context states that there is no correlation between the country effects and the explanatory variables. Rejection of the null hypothesis indicates that modelling the country effects as fixed is more appropriate. See Greene (2000, chapter 14) for more details.

[26] Appendix 2 lists sources and describes the variables used in the analysis. Table 2 provides descriptive statistics.

[27] If convergence holds, the economy of a country will grow faster with a relatively lower level of initial per capita GDP, since it is that much farther away from its steady state and must catch up.

[28] We use average years of secondary schooling in the population 25 years of age and over as a proxy for the stock of human capital.

[29] We use imports plus exports over GDP as a measure of openness to international trade. We try three different measures for both openness to international capital flows (i.e., gross and net private capital flows and foreign direct investment inflows—all as ratios of GDP) and financial sector development (i.e., M2/GDP, private sector credit/GDP, domestic credit provided by banks/GDP). We don't, however, report the results from all of these specifications. The full set of results is available from the authors.

Table 2
Descriptive statistics

	Mean	Stand. Dev.	Min.	Max.
Growth rate of real per capita GDP	1.65	3.07	–7.34	8.82
Real per capita GDP (in log)	7.54	0.73	5.81	9.15
Average years of secondary schooling	1.12	0.65	0.24	3.93
Investment/GDP	23.39	6.97	11.68	41.11
Government consumption/GDP	12.15	4.51	3.65	34.42
(Exports plus imports)/GDP	57.93	31.92	15.06	221.90
M2/GDP	32.29	16.09	9.74	95.64
Private sector credit/GDP	36.99	23.85	0.00	138.79
Domestic credit by banking sector/GDP	50.11	31.98	0.00	185.97
Gross private capital flows/GDP	9.93	29.75	0.51	213.19
Net private capital flows/GDP	2.97	2.78	–1.13	13.23
Net foreign direct investment/GDP	1.55	2.03	–0.85	14.11
CPI inflation	125.01	570.57	0.87	5,085.74

Notes: Based on five-year averages for the 1973–98 period.
In percentage points, unless otherwise indicated.

accumulation is expected to lead to higher real per capita GDP growth.[30] The government consumption variable, as Barro and Sala-i-Martin (1995) point out, is intended to capture public expenditures that do not directly affect productivity but could distort private sector decisions. The coefficient on that variable is thus expected to be negative. On the other hand, the effects of international trade, international capital flows, and financial sector development on growth are all expected to be positive, as discussed in section 1.

In addition to these explanatory variables, we include a dummy variable to account for the nature of the exchange rate regime, our main variable of interest. As mentioned in section 2, we use two exchange rate regime classification schemes: the official classification and our HMR. In each case, the dummy variable takes on the value of 0 for a fixed exchange rate regime,

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[30] In this framework, any effects of the exchange rate regime on growth through the investment channel would be captured by the coefficient on the investment rate. Indeed, it has been argued that a fixed regime could promote growth by increasing investment (see, for instance, Aizenman 1994). However, this is not something that we can test for in our framework, because our dependent variable is growth, not investment.

1 for an intermediate regime, and 2 for a flexible regime.[31] Finally, we include a dummy variable that captures a change in the nature of the regime during the five-year interval.[32]

As outlined in section 1, we test several hypotheses regarding the relationship between the exchange rate regime and growth. First, we test whether the nature of the exchange rate regime influences economic growth, although it is unclear, a priori, whether a more or less flexible exchange rate arrangement will tend to be associated with higher growth. Thus, the expected sign on the exchange rate regime coefficient is ambiguous. Second, we test for evidence to support the notion that a change in regime is linked with lower economic growth, given that such a change is often associated with a costly crisis. The anticipated sign on this variable is therefore negative.

Third, we explore the supposition that the effect of the exchange rate arrangement on growth will be more pronounced for countries that are relatively more open to international trade and capital flows. We test for this by adding interaction terms between the dummy variable for the exchange rate regime and our measures of openness to international trade and international capital flows. Finally, we investigate the idea that a country must have a fairly well-developed financial market to benefit from the growth-promoting attributes of a more flexible arrangement. An interaction term between the level of financial sector development and the exchange rate dummy is included in the regression specification to test for this hypothesis. As discussed in section 1, we would expect the signs on these interaction terms to be positive, except for the one on international trade, which is ambiguous, a priori.

As noted, equation (1) was estimated on a sample of 25 emerging-market countries with data from 1973 to 1998 set up in five-year periods.[33] We selected our sample to generate a wide enough variety of country experiences with exchange rate regimes, without creating a sample where the countries had such dramatically different levels of development that the assumption of common slope parameters would become unreasonable. We

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[31] Since we are using five-year periods, this variable captures the average or typical regime during this interval. In cases where the classification changed during the five-year period, the typical regime is the one that occurred most of the time (i.e., at least three out of five years).

[32] The dummy variable takes on the value 1 if there has been at least one change in the annual classification of the regime over the five-year period. Otherwise, it takes on the value 0.

[33] Not all data series are complete for all countries; the panel-data set is thus unbalanced.

Table 3
Estimation results
Dependent variable: Growth rate of real per capita GDP
Panel data, fixed-effect estimates for 1973–98 using five-year periods

ER regime classification	OC	HMR	OC	HMR
Initial real per capita GDP	–0.068***	–0.067***	–0.075***	–0.074***
	(0.000)	(0.000)	(0.000)	(0.000)
Average years of schooling	0.006	0.007	0.004	0.005
	(0.581)	(0.561)	(0.698)	(0.674)
Investment/GDP	0.053	0.049	0.036	0.033
	(0.399)	(0.428)	(0.558)	(0.588)
Government consumption/GDP	–0.246***	–0.254***	–0.257***	–0.263***
	(0.006)	(0.004)	(0.003)	(0.002)
(Exports plus imports)/GDP	0.003	0.003	–0.001	–0.001
	(0.840)	(0.827)	(0.948)	(0.958)
M2/GDP	0.053*	0.049	0.056*	0.053*
	(0.096)	(0.119)	(0.072)	(0.089)
Gross capital flows (GCF)/GDP	0.024	0.025	0.025	0.026
	(0.154)	(0.142)	(0.124)	(0.115)
Exchange rate regime	0.000	–0.003	–0.000	–0.003
	(0.996)	(0.538)	(0.974)	(0.551)
Exchange rate regime change			–0.010**	–0.010**
			(0.042)	(0.043)
Number of observations	100	100	100	100
Adjusted R-squared	0.68	0.68	0.70	0.70
Hausmann test (*p*-value)	0.0002	0.0001	0.0001	0.0000

Notes:

OC = official classification; HMR = hybrid mechanical rule.

The figures in parentheses are *p*-values.

(***), (**), and (*) indicate statistical significance at the 1 per cent, 5 per cent, and 10 per cent levels, respectively.

Period dummies are included in each regression.

therefore chose a group of emerging-market countries in Latin America and Asia (listed in Appendix 1).

4 Estimation Results

The estimation results are shown in Tables 3 to 5. They are reported for various specifications using the fixed-effects model, given that the Hausmann specification test suggests that it is more appropriate to model the

Table 4
Estimation results
Dependent variable: Growth rate of real per capita GDP
Panel data, fixed-effect estimates for 1973–98 using five-year periods

ER regime classification	OC	HMR	OC	HMR
Initial real per capita GDP	–0.066***	–0.067***	–0.065***	–0.064***
	(0.000)	(0.000)	(0.000)	(0.000)
Average years of schooling	0.000	0.004	0.002	0.006
	(0.973)	(0.745)	(0.880)	(0.612)
Investment/GDP	0.131**	0.144**	0.126*	0.126**
	(0.050)	(0.029)	(0.056)	(0.051)
Government consumption/GDP	–0.252***	–0.260***	–0.263***	–0.265***
	(0.006)	(0.003)	(0.004)	(0.003)
(Exports plus imports)/GDP	0.011	0.006	–0.004	–0.004
	(0.468)	(0.678)	(0.777)	(0.770)
Credit provided by banks/GDP	–0.012	–0.013	–0.009	–0.010
	(0.195)	(0.148)	(0.334)	(0.260)
Gross capital flows (GCF)/GDP	0.010	0.013	0.015	0.020
	(0.594)	(0.434)	(0.373)	(0.225)
Exchange rate regime	–0.005	–0.010	–0.007	–0.011**
	(0.241)	(0.049)	(0.153)	(0.043)
(GCF/GDP) X exchange rate regime	0.033*	0.059**		
	(0.071)	(0.022)		
(Trade/GDP) X exchange rate regime			0.006*	0.007*
			(0.064)	(0.039)
Number of observations	100	100	100	100
Adjusted R-squared	0.69	0.70	0.69	0.69
Hausmann test (p-value)	0.0004	0.0001	0.0008	0.0004

See notes for Table 3.

country effects as fixed rather than random.[34] A test for the joint significance of the country dummies reveals that a fixed-effects specification would be preferable to pooled ordinary least squares.[35] As indicated by the adjusted R^2s, the model explains between 68 and 70 per cent of the variation in the growth rates in our sample.

The signs of the coefficients on the explanatory variables other than the exchange rate regime variables are generally statistically significant and consistent with theory. The coefficients on initial real per capita GDP and the government's share of real GDP are negative, whereas the coefficients on

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[34] As shown by the reported p-values, the null hypothesis of the Hausmann test (i.e., no correlation between the country effects and the explanatory variables) is rejected in all cases.

[35] P-values are also reported for a test of the joint significance of the time dummies, which suggests that it is appropriate to include them in the regressions.

Table 5
Estimation results
Dependent variable: Growth rate of real per capita GDP
Panel data, fixed-effect estimates for 1973–98 using five-year periods

ER regime classification	OC	HMR
Initial real per capita GDP	–0.069***	–0.067***
	(0.000)	(0.000)
Average years of schooling	0.000	0.004
	(0.975)	(0.709)
Investment/GDP	0.080	0.081
	(0.212)	(0.201)
Gov't consumption/GDP	–0.262***	–0.265***
	(0.003)	(0.002)
(Exports plus imports)/GDP	–0.005	–0.005
	(0.755)	(0.754)
M2/GDP	0.033	–0.029
	(0.321)	(0.380)
Gross capital flows (GCF)/GDP	0.014	0.018
	(0.420)	(0.281)
Exchange rate regime	–0.009	–0.012*
	(0.169)	(0.082)
(M2/GDP) X exchange rate	0.027*	0.032*
	(0.088)	(0.086)
Number of observations	100	100
Adjusted R-squared	0.69	0.69
Hausmann test (*p*-value)	0.0001	0.0002

See notes for Table 3.

the investment rate and the measure of banking sector development are positive. The coefficients on the proxy for human capital and the measures of international openness are not statistically significant, however.

Table 3 reports the results of the regressions we used to test our first two hypotheses. For each specification, we report the results using both methods of classification. As shown in the first and second columns, the coefficient on our dummy variable for the exchange rate regime—for both classification schemes—is not statistically significant. Thus, we do not find support for our first hypothesis: that the nature of the exchange rate regime influences economic growth. We do, however, find evidence that a change in the regime is associated with lower medium-term growth. Indeed, as shown in the third and fourth columns, the coefficient on the dummy variable capturing a change in the exchange rate regime is negative and statistically significant for both classification schemes. Moreover, this result is robust to specification changes.[36]

We do find evidence, however, that more flexible exchange rate arrangements are associated with higher economic growth when we allow the effect of the regime on growth to differ based on a country's degree of openness to international trade and capital flows. As shown in Table 4, the interaction terms between the exchange rate regime and the measures of openness to trade and capital flows are all positive and statistically significant, regardless of which classification scheme is used. This suggests that the effect on growth of a more flexible arrangement is more pronounced when the country is more open. Interestingly, the coefficient on the exchange rate regime dummy becomes negative when the interaction terms are included, but only for our HMR classification scheme. Thus, the results with our mechanical rule suggest that flexible exchange rate arrangements will be associated with higher growth *only* for countries that are relatively open to trade and capital flows. For other countries, a more flexible arrangement is actually *detrimental* to growth. Again, we found these results to be robust to specification changes.

Based on the estimated coefficients in the regressions using the HMR in Table 4, we find that a more flexible exchange rate arrangement will be growth-promoting, as long as gross capital flows represent at least 17 per cent of GDP, and as long as trade as proportion of GDP exceeds 157 per cent. We calculated average values for these variables over the sample period to determine which countries, and how many, would be considered open enough to benefit from a more flexible exchange rate arrangement. As shown in Appendix 3, very few countries have variable values that are above the calculated thresholds. We realized, moreover, that these countries had values for the variables that were much higher than in the sample average. We removed them from the sample and re-estimated the regressions to determine whether our results were being driven by these outliers.

Once the outliers were removed from the sample, we found that the results were very similar for gross capital flows when using the HMR to classify regimes, except that the estimated coefficients on both the exchange rate regime variable and the interaction term increased in absolute terms.[37] This resulted in a decline in the calculated threshold for gross capital flows from

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[36] This result did not change when we added other variables, such as inflation or population growth, or when we used different measures of financial sector development.

[37] The coefficient on the exchange rate dummy becomes –0.016 (compared to –0.10) and the coefficient on the interaction term becomes 0.26 (compared to 0.06).

17 per cent to 6 per cent of GDP.[38] It appears that the outliers reduced the size of the coefficient on the interaction term but did not change the basic result. Thus, the result (using our mechanical rule) appears robust not only to specification changes, but also to the presence of outliers. When the official classification was used, however, the coefficient on the interaction term with international capital flows became insignificant.

This was also the case for the evidence we found related to the exchange rate regime and international trade. Once we removed the outliers, the coefficients on the exchange rate variable and the interaction term with international trade both became insignificant. It appears that this result was driven by a few countries that were very open to international trade and that could not be generalized to the rest of the sample countries.

Finally, we found evidence to suggest that a country must have fairly well-developed financial markets to benefit from a flexible exchange rate arrangement. As shown in Table 5, the coefficient on the interaction term between financial sector development and the exchange rate regime is positive and statistically significant for both types of classification schemes. The coefficient on the exchange rate regime is negative, but only when using our mechanical rule to classify regimes. This suggests that more flexible arrangements will have a positive effect on growth for countries that have relatively well-developed financial sectors. For countries that have less developed financial sectors, our results differ depending on the classification scheme used. Results using the official classification suggest that flexible exchange rate arrangements are associated with higher growth for all countries, but that the effect on growth is more pronounced the more developed its financial sector. On the other hand, the results using the HMR suggest that flexible exchange rate arrangements will be associated with higher growth *only* in countries that have well-developed financial sectors. For other countries, a more flexible arrangement is actually *detrimental* to growth. This result, however, was only somewhat robust to specification changes.[39]

Based on the estimated coefficients in the regressions using the HMR in Table 5, we find that a more flexible exchange rate arrangement will be growth-promoting as long as M2 exceeds 38 per cent of GDP. As shown in Appendix 3, eight countries in our sample have average values for M2/GDP that exceed this threshold value. And, unlike the case for our measures of openness, it does not appear that there are any significant outliers based on this measure of financial sector development.

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[38] The following seven countries have ratios of gross capital flows to GDP that are higher than the threshold value of 6 per cent: Chile, Korea, Malaysia, Panama, Singapore, Uruguay, and Venezuela.

[39] This result held when variables such as inflation and population growth were added, but it did not hold when different measures of financial sector development were tried.

These results are subject to an important caveat. The methodology that we use does not account for the possibility that some of the explanatory variables might be endogenous. We attempted to address this issue by using a generalized method of moments estimation technique, following Caselli, Esquivel, and Lefort (1996), in which lagged values of the explanatory variables are used as instruments. We do not report these results because they were not very robust, and in some cases, they were significantly different from what has been reported in the literature. We do, however, plan to pursue this issue in subsequent research.

Conclusion

Using a panel-data set of 25 emerging-market countries over the 1973–98 period, this study found evidence that the nature of the nominal exchange rate regime might matter for economic growth. Two of our estimation results are quite robust. First, we find evidence—using our HMR for classifying exchange rate regimes—suggesting that flexible exchange rate arrangements will be associated with higher growth *only* in countries that are relatively open to capital flows. Second, our results indicate that a change in the exchange rate regime is linked with lower economic growth. We also found evidence, although it is less robust than our other results, that implies that a country must have fairly well-developed financial markets to benefit from a flexible exchange rate arrangement. Further research will need to determine whether these results are influenced by the potential endogeneity of the explanatory variables.

The fact that we found evidence linking the exchange rate regime and growth—where previous work has not—and that our results differ based on the classification scheme used, supports the view that measurement error in the classification of exchange rate arrangements is an important issue. Indeed, our ability to provide conclusive empirical evidence to answer questions such as the one this paper poses is dependent on the development of appropriate exchange rate regime classification schemes. We therefore welcome efforts to develop classification schemes that more accurately reflect reality.

Our findings suggest that we could witness a drift towards more flexible exchange rate arrangements as emerging markets become more integrated with international capital markets, given that there might be benefits in terms of higher growth. However, our alternative regime classification suggests that the 25 emerging markets in our sample have not generally being moving in the direction of more flexible arrangements. Of course, as our study confirms, exchange rate flexibility is not in itself sufficient to promote medium-term growth. Emerging-market countries may also be reluctant to float, since they may have limited means of conducting their own monetary policy and of dealing with exchange rate volatility. In addition, as Laidler (1999) notes, exchange rate flexibility must be accompanied by a credible nominal anchor, such that a country's monetary policy constitutes, in his terms, a "coherent monetary order." Over the past few years, an increasing number of emerging-market countries have opted to combine a floating exchange rate regime with an inflation-targeting framework. As such regimes become more common in emerging-market countries, we may begin to notice a less pronounced "fear of floating."

Appendix 1
List of Countries

Argentina
Bolivia
Brazil
Chile
China
Colombia
Costa Rica
Ecuador
El Salvador
Guatemala
Guyana
Honduras
Hong Kong
Indonesia
Korea
Malaysia
Mexico
Nicaragua
Panama
Paraguay
Philippines
Singapore
Thailand
Uruguay
Venezuela

Appendix 2
Sources and Definitions of Variables

Dependent variable

1. Growth rate of real per capita GDP over a five-year period (calculated using data on real per capita GDP taken from the World Bank's *World Development Indicators* (*WDI*)).

Explanatory variables

2. Real per capita GDP at the beginning of each five-year period (calculated using data on real per capita GDP taken from the World Bank's *WDI*).
3. Ratio of real investment to real GDP measured in five-year averages (calculated using real investment and real GDP data taken from the World Bank's *WDI*).
4. Average years of secondary schooling of the population aged 25 and over at the beginning of each five-year period (taken from the Barro-Lee data set on educational attainment).
5. Real government share of GDP measured in five-year averages (calculated using real government consumption and real GDP data from the World Bank's *WDI*).
6. Ratio of real (exports plus imports) to real GDP measured in five-year averages (calculated using real export, import, and GDP data from the World Bank's *WDI*).
7. Ratio of money and quasi money (M2) to GDP measured in five-year averages (taken from the World Bank's *WDI*).
8. Ratio of private sector credit to GDP measured in five-year averages (taken from the World Bank's *WDI*).
9. Ratio of domestic credit provided by banking sector to GDP measured in five-year averages (taken from the World Bank's *WDI*).
10. Ratio of gross private capital flows to GDP measured in five-year average (taken from the World Bank's *WDI*).
11. Ratio of net private capital flows to GDP measured in five-year averages (taken from the World Bank's *WDI*).
12. Ratio of net foreign direct investment inflows to GDP measured in five-year averages (taken from the World Bank's *WDI*).
13. Dummy variable for type of exchange rate regime (see section 3 for more details).
14. CPI inflation measured in five-year averages (taken from the World Bank's *WDI*).
15. Population growth measured in five-year averages (taken from the World Bank's *WDI*).

Appendix 3
Countries Above Threshold Values for Variables in Interaction Terms

Trade/GDP

Guyana
Hong Kong
Singapore

Gross capital flows/GDP

Panama
Singapore

M2/GDP

China
Costa Rica
Guyana
Hong Kong
Malaysia
Panama
Singapore
Thailand

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Discussion

Paul Masson

This is an interesting and well-crafted paper on a topical subject. Since the 1991 Maastricht Treaty to create a monetary union in Europe and the 1994 and 1997 currency crises affecting emerging-market countries, the literature on exchange rate regimes has exhibited explosive growth. Some of it has taken quite a narrow and dogmatic perspective: that currency unions or floating rates must be good because they eliminate exchange rate crises. The authors of this paper rightly expand their focus to determine whether the ultimate objectives of economic policy—in particular, economic growth—are helped or hindered by one exchange rate regime or another. Empirical examination of the optimality of exchange rate regimes has given rise to only a few articles, two of which stand out. Ghosh et al. (1997) find that currency boards lead to lower inflation at no cost to growth, while Rose (2000) finds that currency unions increase the internal trade within the union by a factor of three, after controlling for other determinants in the context of a gravity model. This, and the fact that trade is associated with higher growth (e.g., Frankel and Rose 2000), lead him to link currency unions to higher growth.

The paper by Bailliu, Lafrance, and Perrault takes a different tack and focuses on the growth-enhancing effects of flexible exchange rates. While the authors admit that theory does not suggest any very strong hypotheses concerning exchange rate regimes and growth, it is clear that their priors are that flexibility, by limiting the likelihood and severity of crises, should be positive (or at least neutral) for medium-term growth. They test this by including a dummy for the exchange rate regime in a panel regression for 25 merging-market countries where growth is regressed on other plausible determinants. Unfortunately, the initial results suggest, if anything, a small negative but insignificant effect of greater flexibility, although a change of regime within the period (in whatever direction) appears harmful to growth.

Subsequent regressions suggest that if the exchange rate regime dummy variable is also interacted with either gross capital flows as a ratio to GDP, trade flows as a ratio to GDP, or M2/GDP, flexibility has the expected positive effect—but only for countries above a certain threshold for those variables. The authors conclude that exchange rate flexibility is a good thing for countries that are sufficiently open or that have a sufficient level of financial development.

As in all such empirical investigations, a crucial issue is the robustness of the results to changes in specification or data sets. To their credit, the authors test whether the result with respect to the interaction of trade/GDP and the exchange rate dummy is due to a few outliers. They conclude that it is. More fundamentally, one could question their choice of 25 emerging-market countries, and whether a larger data set including all countries for which data are available—which, in practice, would amount to well over 100—would have been more relevant. No doubt their motivation was to examine those countries for which high capital mobility makes adjustable pegs fragile, but even among this set of countries, the authors find it necessary to distinguish between various degrees of capital-market openness and financial development.

In fact, it is by no means clear that these 25 countries are the obvious "emerging markets." In a study of exchange rate regime transitions (Masson 2001), for example, I selected for my set of emerging-market countries those 27 countries included in J.P. Morgan's Emerging Markets Bond Index (EMBI) Global. This leads to an obvious question: are the authors' 25 emerging markets all included in the latter? The answer may surprise you: in fact, 13 of them are not on J.P. Morgan's list. Among these 13 are a number of the smaller Latin American countries (Bolivia, Costa Rica, El Salvador, Guatemala, Guyana, and Paraguay). Conversely, J.P. Morgan's list includes 14 countries that are not on the authors' list, among them several important emerging markets in Eastern Europe (Hungary, Poland, and Russia), as well as South Africa and Turkey and a number of smaller countries. Indeed, the authors' list consists exclusively of Latin American and East Asian countries, while the J.P. Morgan index has a wider geographical representation. Perhaps the existence of only a decade or so of relevant data on transition economies dictated the authors' omission of them from their panel, but it would have been preferable then to work with an (even more) unbalanced panel to obtain a broader representation. More generally, the authors' hypothesis (the effect of regime choice on growth) is relevant to all countries, and in any case, their inclusion of a variable capturing the interaction of the regime with financial or trade ratios facilitates including countries at all stages of development.

Another issue raised by the authors is the vexing one of the exchange rate regime classification. Historically, there could be a large gap between how the countries officially classified themselves for the IMF and what they did in practice. This was especially true of some of the Asian-crisis countries that declared themselves as following a flexible rate regime, while their currencies hardly varied against the U.S. dollar. This implicit commitment was well understood by financial markets, and when the central banks were forced by a speculative attack to let go of the peg, a loss of credibility resulted. But the crises also tended to bring actual practice closer to declared regimes, by forcing countries off their de facto pegs. In future, a new classification (IMF 1999) should provide a better description of the regimes countries actually follow, but this will not clarify the historical data.

In addition to countries with official pegged rate regimes, the authors include those with annual volatility of less than 0.45 percentage points against the U.S. dollar. The more flexible regimes are then classified into intermediate and flexible rates based on a flexibility index relative to a regional average: those less than unity are intermediate, while those greater than unity are flexible. This gives a tripartite classification that is used to create a dummy variable, with a zero for fixes, a one for intermediates, and a two for flexible rates.

The authors then examine the sign and significance of the coefficient of this dummy variable in panel-growth regressions, as well as the coefficient of a dummy variable created from the official classification. Results are qualitatively and even quantitatively similar for the two classifications. However, I would have liked to have seen more theoretical justification for their classification system, as well as tests of the robustness of results to tweaking the criteria. For instance, the intermediate and flexible categories depend on what regional neighbours are doing—why not a uniform volatility threshold to apply to all countries? Why is there the choice of a cut-off of 0.45 per cent for inclusion among fixed rates, rather than a larger or smaller number?

An alternative approach is to let the data dictate the threshold levels. This is done, for example, by Levy Yeyati and Sturzenegger (1999) in their exchange rate regime classification of 110 countries. They use cluster analysis applied to exchange rate and foreign exchange reserve changes to classify regimes into pegs, crawling pegs, bands, and flexible rates. I compared the 1997 regimes from their classification (lumping crawling pegs and bands together into an intermediate category) with the Bank of Canada classification for 1993 to 1997 for the 17 countries appearing on both lists (ignoring those that Levy Yeyati and Sturzenegger could not classify). Of these 17, 11 of them had different classifications in the Bank of Canada and

Levy Yeyati and Sturzenegger data sets! So the crucial dummy variable in the present paper is by no means free from possible measurement error. Also note that the implicit weighting of intermediate and flexible regimes in the dummy variable is arbitrary, and it implies that whatever effect flexibility has on growth, fully flexible regimes exhibit twice that effect relative to intermediate ones, when compared with fixed rates. A more general (and satisfactory) procedure would be to include two dummy variables: fix versus flex and flex versus intermediate.

I would be remiss in my role as discussant if I did not raise a few other important econometric issues related to the paper. One is of endogeneity, which was touched on but not satisfactorily resolved in the paper. The problem seems especially obvious in the case of the interaction variables: exchange rate regimes are often argued to have an effect on opennness (i.e., the extent of trade and capital flows), while openness here is interacted with the dummy variable to gauge the effect of exchange rate regimes. A second issue is the use of five-year averages instead of annual data. This approach tends to throw away information, while not solving endogeneity problems. It also leads to an awkward interpretation of the change in regime variable: this is a dummy "that captures a change in the nature of the regime during the five-year interval (page 332)." One would assume that the timing of the change (beginning or end) should matter for growth—how is this handled? And if the regime change occurs at the end of a five-year period, is it allowed to have any effect on the subsequent period?

I welcome the authors' serious attempt to address an important issue: the effect of exchange rate regime on things we really care about, such as growth. For the reasons I have outlined, I am not convinced that the answer provided in the paper—that exchange rate flexibility is good for growth in economies with a sufficient level of openness or financial development—will stand up to testing with a wider set of countries, alternative regime classifications, or different estimation techniques. I would encourage the authors to pursue some of these issues in future related work.

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The Mirage of Floating Exchange Rates†

Carmen M. Reinhart*

During the past few years, many countries have suffered severe currency and banking crises, producing a staggering toll on their economies, particularly in emerging-market countries. In many cases, the cost of restructuring the banking sector has been in excess of 20 per cent of GDP, and output declines in the wake of crisis have been as large as 14 per cent. An increasingly popular view blames fixed exchange rates, specifically "soft pegs," for these financial meltdowns. Not surprisingly, adherents to that view advise emerging markets to join the ranks of the United States and other industrial countries that have chosen to allow their currency to float freely. (See, for example, Goldstein 1999.)

At first glance, the world—with the notable exception of Europe—does seem to be marching steadily towards floating exchange rate arrangements. According to the International Monetary Fund (IMF), 97 per cent of its member countries in 1970 were classified as having a pegged exchange rate; by 1980, that share had declined to 39 per cent, and in 1999, it was down to only 11 per cent.[1] Yet, this much-used IMF classification takes at face value that countries actually do what they say they do. Even a cursory perusal of the Asian crisis countries' exchange rates prior to the 1997 crisis would suggest that their exchange rates looked very much like pegs to the U.S. dollar for extended periods of time. Only Thailand, however, was explicitly classified as a peg; the Philippines was listed as having a freely floating exchange rate, while the others were lumped under the catch-all label of managed floating.

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[1] Obstfeld and Rogoff (1995) make this point, as well.

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In this paper, I summarize some of the key findings of Calvo and Reinhart (2000), who analyze the behaviour of exchange rates, foreign exchange reserves, the monetary aggregates, and interest rates across the spectrum of exchange rate arrangements to assess whether the "official labels" provide an adequate representation of actual country practice. To illustrate some of the main points, I present evidence for a few regimes that are drawn from the analysis of a much larger population of exchange rate arrangements. The data span monthly observations for 36 countries during the January 1970 to April 1999 period.

Some of the key findings are: (i) Countries that say they allow their exchange rate to float mostly do not. There seems to be an epidemic case of "fear of floating." Relative to more committed floaters, such as the United States, Australia, and Japan, observed exchange rate variability is quite low. The low variability of the nominal exchange rate is not owing to the absence of real or nominal shocks in these economies. Indeed, relative to the United States and Japan, most of these countries are subject to larger and more frequent shocks to their terms of trade—hardly surprising, given the high primary commodity content of their exports, in many cases. (ii) The low relative exchange rate variability is the deliberate result of policy actions to stabilize the exchange rate. Reserve volatility (contrary to what we should expect in the context of a floating exchange rate or relative to what we observe in the more committed floaters) is very high. (iii) Interest rate volatility (both real and nominal) is significantly higher—and in a different league altogether—from that of the true(r) floaters. The high volatility in both real and nominal interest rates appears to have had two main explanations. It suggests that countries are not relying exclusively on foreign exchange market intervention to smooth fluctuations in the exchange rates—interest rate defences are commonplace. The high variability of interest rates also suggests that there are chronic credibility problems. (iv) Since countries that are classified as having a managed float mostly resemble non-credible pegs, the so-called "demise of fixed exchange rates" is a myth. Instead, the fear of floating is pervasive, even among some of the developed countries.[2] Our finding, that most of the episodes that come under the heading of floating exchange rates look more like non-credible pegs, may help explain why earlier studies, which relied on the official classifications of regimes, failed to detect important differences in GDP growth rates and inflation, across peg and the floating regimes (see Ghosh et al. 1997).

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[2] See Calvo and Reinhart (2000) for a fuller discussion of why there is fear of floating.

Section 1 provides a brief review of what economic theory predicts for the behaviour of exchange rates, foreign exchange reserves, the monetary aggregates, and interest rates across the spectrum of exchange rate arrangements. Section 2 confronts these theoretical priors with the actual data, while section 3 discusses some of the reasons for "fear of floating."

1 Basic Concepts

Let i and i^* denote the domestic and foreign nominal interest rate, respectively, while E is the nominal exchange rate. The expected devaluation rate and default risk premiums are given by ε and ρ, respectively, and R denotes the level of foreign exchange reserves. The variance of any variable, x, is denoted by $Var(x)$.

Now let us first consider a floating exchange rate regime with a money-supply rule, under which shocks to money demand, expectations about the exchange rate, or default risk are not accommodated. Under such circumstances, one should expect to see in the data that: $Var(E) > 0$; $Var(i) > 0$, to the extent that there are shocks to the demand for money; and $Var(R) = 0$, since there is no central bank intervention. If, as in the United States, there is no explicit targeting of monetary aggregates, the exchange rate floats, and interest rates are smoothed, then shocks to money demand are accommodated, but shocks to exchange rate expectations or the default risk premiums are not. In this case, $Var(E) > 0$, $Var(i) = 0$, $Var(R) = 0$, since money supply adjusts through open market operations rather than through purchases and sales of foreign exchange reserves.

At the other extreme, if a country has a fully credible peg (which is defined to include the confidence that there would be no default), the interest-rate-parity condition is simply $i = i^*$. In that case, we should expect: $Var(E) = 0$; $Var(i) = Var(i^*)$ because of full credibility; and $Var(R) > 0$, since money-demand shocks are accommodated. Non-credible pegs, which include likelihood of default and are much more common, break down the one-to-one relationship between i and i^*. As before, $Var(E) = 0$ and $Var(R) > 0$, but now the interest-rate-parity condition is given by:

$$i = i^* + \varepsilon + \rho, \tag{1}$$

$$Var(i) = Var(i^*) + Var(\varepsilon) + Var(\rho) + \text{covariance terms}. \tag{2}$$

Hence, lack of credibility implies that $Var(i) > Var(i^*)$.

However, as noted earlier, countries frequently depart from their stated exchange rate arrangements. Pegs or quasi-pegs are not always made explicit. One increasingly common form of "peg-in-disguise" or "Fear of

Floating I" (Table 1) is when the exchange rate is stabilized through open market operations, rather than through purchases and sales of foreign exchange. Examples of this type of arrangement include Peru since August 1990 and Mexico since December 1994. Assuming imperfect credibility (since the arrangement is not made explicit), the implications are identical to that of the non-credible peg (i.e., $Var(E) = 0$, $Var(i) = Var(i^*) + Var(\varepsilon) + Var(\rho)$ + covariance terms) except $Var(R) = 0$. If, despite having an announced float, the attempt to stabilize the exchange rate is less well disguised (as is the case of South Korea from 1999 to the present), the predictions from theory are hardly distinguishable from a non-credible peg. This case is depicted in Table 1 in the row designated by "Fear of Floating II."

Table 1
Predicted behaviour under alternative exchange rate arrangements

Exchange rate arrangement	$Var(E)$	$Var(i)$	$Var(R)$
Float/money-supply rule	high	?	0
Float/interest rate smoothing	high	low	0
Credible peg	0	$Var(i^*)$	?
Non-credible peg	0	high	high
Non-credible quasi-peg in disguise (Fear of Floating I)	low	high	low
Non-credible quasi-peg in less of a disguise (Fear of Floating II)	low	high	high

Having reviewed the theoretical priors of what to expect from the behaviour of exchange rates, international reserves, and interest rates across exchange rate regimes (which are summarized in Table 1), we proceed to confront these priors with the actual data.

2 The Evidence

Our data are monthly for 36 countries in Africa, Asia, Europe, and the western hemisphere from January 1970 to April 1999. Selected examples are presented here, and the full range of episodes are given in Calvo and Reinhart (2000). Countries are grouped into four types of exchange rate arrangements according to IMF classification: peg, limited flexibility, managed floating, and freely floating. Limited flexibility has almost exclusively been used to classify European countries (prior to the monetary union) with exchange rate arrangements vis-à-vis one another (i.e., the Snake, the Exchange Rate Mechanism, etc.).

Despite occasional bouts of foreign exchange market intervention, sometimes even in coordinated fashion, the United States dollar (US$) floated about as freely against the German deutschemark (DM), and now the euro and the Japanese yen (¥), as any currency is allowed to float. For this reason, we compare countries that have regimes that are classified as freely floating or managed floating against this "G-3" benchmark. Given well-defined priors for the behaviour of exchange rates, foreign exchange reserves, the monetary aggregates, and interest rates across the spectrum of exchange rate arrangements, we proceed by examining these variables one at a time. In what follows, we analyze monthly percentage changes.

Table 2 presents evidence of the frequency distribution of monthly exchange rate changes (in percentages). For the United States, for example, there is about a 59 per cent probability that the monthly US$/DM exchange rate change falls within a relatively narrow ±2.5 per cent band. By contrast, for Bolivia, Canada, and India (all declared floaters during that period), that probability is in the 94 to 96 per cent range.[3] An alternative way of stating the same facts is that there is only about a 5 per cent probability in those countries that an exchange rate change will exceed 2.5 per cent on any given month (versus more than 40 per cent for the US$/DM). The absence of moderate-to-large monthly fluctuations in the exchange rate is equally absent among the so-called "managed float" episodes (Table 3). For Egypt and Bolivia, the probability of a monthly exchange rate change greater than 2.5 per cent is nil. Even for self-proclaimed flexible rate advocates, such as Chile and Singapore, the frequency distribution of their monthly exchange rate fluctuations relative to the U.S. dollar does not vaguely resemble that of the US$/DM or US$/¥, with a significantly higher proportion of observations falling within a narrow band. By this metric, post-crisis Mexico approximates a float more closely than any of the others, including Canada.

As discussed in the previous section, however, exchange rates tell only part of the story. We cannot glean from exchange rates alone what would have been the extent of exchange rate fluctuations in the absence of policy interventions; that is, we do not observe the counterfactual. To assess the extent of policy intervention to smooth out exchange rate fluctuations, we examine the behaviour of foreign exchange reserves. As Table 1 highlights, the variance of reserves should be zero in a pure float. In reality, reserves may also change, owing to changes in valuation. Table 4 reports excerpts from the frequency distribution of monthly reserve changes (in U.S. dollars). With the exception of the United States, most countries in Table 4 hold the lion's share of their foreign exchange reserve holdings in dollar-

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[3] These patterns are representative of a broader set of countries (see Calvo and Reinhart 2000).

Table 2
Exchange rate volatility in recent or current "floating" exchange rate regimes

Country	Period	Probability that monthly percentage change falls within	
		±1 per cent band	±2.5 per cent band
United States $/DM	February 1973–April 1999	26.8	58.7
Japan	February 1973–April 1999	33.8	61.2
Bolivia	September 1985–December 1997	72.8	95.9
Canada	June 1970–April 1999	68.2	93.6
India	March 1993–April 1999	82.2	93.2
Mexico	December 1994–April 1999	34.6	63.5

Table 3
Exchange rate volatility in recent or current "managed" exchange rate regimes

Country	Period	Probability that monthly percentage change falls within	
		±1 per cent band	±2.5 per cent band
United States $/DM	February 1973–April 1999	26.8	58.7
Japan	February 1973–April 1999	33.8	61.2
Bolivia	January 1998–April 1999	100.0	100.0
Chile	October 1982–April 1999	45.5	83.8
Egypt	February 1991–December 1998	95.7	98.9
Pakistan	January 1982–April 1999	77.8	92.8
Singapore	January 1988–April 1999	61.5	89.6

denominated assets; hence, valuation changes are not an issue. As Table 4 highlights, there is about a 74 per cent probability that Japan's monthly changes in foreign exchange reserves fall in a narrow ±2.5 per cent band. In the case of Mexico, there is only about a 28 per cent probability that changes are that small, while in the case of Bolivia, that probability is even lower. Indeed, for all other countries, large swings in foreign exchange reserves appear commonplace, consistent with a higher extent of intervention in the foreign exchange market—even relative to what is to be expected a priori from a freely floating exchange rate regime.

Policy intervention to smooth exchange rate fluctuations does not appear limited to transactions in foreign exchange markets. While interest rates in

Table 4
Foreign exchange reserve volatility in recent or current "floating" exchange rate regimes

Country	Period	Probability that monthly percentage change falls within	
		±1 per cent band	±2.5 per cent band
United States	February 1973–April 1999	28.6	62.2
Japan	February 1973–April 1999	44.8	74.3
Bolivia	September 1985–December 1997	8.1	19.6
Canada	June 1970–April 1999	15.9	36.6
India	March 1993–April 1999	21.6	50.0
Mexico	December 1994–April 1999	13.2	28.3

Notes: Reserves are in U.S. dollars. Since the United States holds its reserves in foreign currencies, much of the fluctuations in these simply reflects valuation changes arising from fluctuations in the dollar.

the United States and Japan are predominantly set with domestic policy objectives in mind, interest rate policy in most of these other countries accords a much higher weight to the stabilization of the exchange rate. It would be difficult to justify the very high relative volatility of nominal and real interest rates in these countries on the basis of changes in domestic "policy fundamentals," as Table 5 makes plain. The probability that interest rate changes will be confined to a narrow ±50-basis-point band for the United States is about 82 per cent—even including the historically turbulent inflation stabilization period of the early 1980s. For Japan, that probability is even higher. By contrast, during Mexico's "floating exchange rate" regime, there is only a 9.4 per cent probability that interest rate changes will be less than or equal to fifty basis points. Such stability in interest rates seems to elude most emerging markets—even those with capital controls, such as India. Indeed, major interest rate changes (by G-3 standards) appear to be the rule. While the probability that interest rates change by 500 basis points (5 per cent) on any given month is about zero for the United States and Japan, that probability is close to 30 per cent for Mexico. A recent example of Mexico's use of high interest rates as a means of limiting exchange rate pressures (despite a slowing economy and an adverse terms-of-trade shock) comes from the aftermath of the Russian crisis in August 1998. Nor is Mexico unique in this regard among emerging markets. Such interest volatility is not the by-product of adhering to strict monetary targets in the face of large and frequent money-demand shocks. In effect, most of these countries do not have explicit or implicit money-supply rules. It is a

Table 5
Nominal interest rate volatility in recent or current "floating" exchange rate regimes

Country	Period	Probability that the monthly change in nominal interest rate falls within ±0.25 per cent band (25 basis points)	Probability that the monthly change in nominal interest rate falls within ±0.5 per cent band (50 basis points)
United States	February 1973–April 1999	59.7	80.7
Japan	February 1973–April 1999	67.9	86.4
Bolivia	September 1985–December 1997	16.3	25.9
Canada	June 1970–April 1999	36.1	61.8
India	March 1993–April 1999	6.4	15.9
Mexico	December 1994–April 1999	5.7	9.4

combination of trying to stabilize the exchange rate (without giving the explicit signal that foreign exchange market intervention yields) and lack of credibility.[4]

3 "Fear of Floating"

Going beyond superficial classifications and taking the wealth of evidence at hand, if results are any guide to the future, promises and statements by countries to move in the direction of a floating exchange rate may be devoid of real consequences. There appears to be a widespread "fear of floating" that is closely linked with credibility problems.

The root causes of the marked reluctance by emerging markets to float their exchange rates are multiple. When circumstances are favourable (i.e., there are capital inflows, positive terms-of-trade shocks, etc.), many emerging-market countries are reluctant to allow the nominal (and real) exchange rate to appreciate. This probably stems from fears of the "Dutch disease" type problems—loss of competitiveness and serious setbacks to export diversification. When circumstances are adverse, the case against allowing large depreciations becomes possibly even more compelling. The fear of a collapse in the exchange rate comes from pervasive liability dollarization, since in most emerging markets the debt of both the government and the private sector is largely denominated in hard foreign currency. For this and other reasons, devaluations in developing countries have a history of being associated with recessions, not export-led booms. Furthermore, the authorities may resist large devaluations because of their inflationary consequences and the credibility problems these may feed.

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[4] The results for real interest rates paint a similar picture; they are available from the author.

If "fear of floating" continues to be the serious policy issue it has been in the past, and if, as the stylized facts on interest rates suggest, lack of credibility remains a serious obstacle, the only way to simultaneously avoid the "floating and credibility problems" may be full dollarization. A corner solution indeed!

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Discussion*

Mark Kruger

Economists have traditionally relied on two tests to identify a country's exchange rate regime. One is "the believe me test," where I tell the IMF which type of exchange rate regime I have and you believe me. The other test is "the duck test," where if it looks like a duck and if it quacks like a duck, it must be a duck. However, Calvo and Reinhart caution us that in order to be a duck, it actually has to float like a duck.

The authors have written a thoughtful paper that challenges the conventional wisdom that countries are moving to the poles of either freely floating or firmly fixed exchange rates. They conclude that many emerging-market countries that claim to have floating exchange rates actually behave as if they are operating under soft pegs. The authors offer a theoretical framework to show that in the context of destabilizing devaluations, countries are afraid to actually let their currencies float. I would agree and add that other countries appear to be afraid to allow their currencies to *appreciate* out of concern for a loss of competitiveness.

I would like to comment on three aspects of the paper. First, what does a floating exchange rate really look like? Second, does a floating exchange rate act as a stabilizer for shocks? And finally, what are the policy implications for a country when devaluations are contractionary?

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* This commentary discusses the paper presented at the conference: "Fear of Floating," by Guillermo A. Calvo and Carmen M. Reinhart.

What Does a Floating Exchange Rate Really Look Like?

To determine the extent to which the exchange rate actually floats, the authors compare one-month changes of the exchange rate across different regimes. While they find that the volatilities for countries that claim to be fixed and countries that claim to be freely floating are significantly different, the differences across other regimes are blurred.

This raises the question of whether the one-month change is the appropriate metric by which to measure the exchange rate regime. In theory, just because an exchange rate is free to change does not mean that it will, in fact, do so. In practice, the data for Canada show that the exchange rate has a very low volatility. Yet this doesn't prevent the dollar from exhibiting significant movement over time.

However, just because the exchange rate is floating does not mean that it is disregarded. In Canada, the exchange rate and interest rates are seen as jointly determining monetary conditions. The Bank of Canada can change monetary conditions, but the market determines how the change will be reflected in the interest rates and the exchange rate (see Freedman 1996, 73). From this perspective, the exchange rate is seen as a tool for keeping inflation on target.

Indeed, it must be emphasized that without a nominal anchor, a floating exchange rate cannot be credible and could be a licence to inflate. In Canada, the inflation targets underpin expectations that the Bank will not allow depreciations to feed into inflation. It is for this reason that emerging-market countries like Mexico and Brazil chose money or inflation targets when they floated their exchange rates.

In Canada, it is because the exchange rate is free to respond to monetary policy's maintenance of low inflation that we say it floats. Moreover, it is only possible for monetary policy to be transmitted through the exchange rate when the authorities have no ulterior exchange rate objectives.

As the authors show, some countries may have an objective for the exchange rate that may not be consistent with what they report to the IMF as the nature of their exchange rate regime. However, the existence of an exchange rate objective cannot simply be deduced from the data either. The role of the exchange rate in the conduct of monetary policy requires careful case-by-case analysis.

From the high volatility of interest rates, the authors conclude that some countries use high interest rates as a means of limiting exchange rate pressures. It is argued that these countries have an objective for the exchange rate, with the authorities preferring to stabilize the exchange rate rather than interest rates.

In conducting monetary policy under floating exchange rates, there are times when disorderly markets make it difficult to achieve the desired level of monetary conditions (see Freedman 1996, 77). A loss of confidence in the currency can generate extrapolative expectations and snowballing movements. To stabilize the market, the central bank might have to encourage (or validate) a rise in interest rates that was larger than needed to simply offset the economic impact of a depreciation. As expectations of a further weakening of the exchange rate dissipate, interest rates could decline to levels consistent with desired monetary conditions. Thus, in these situations, it may appear that the central bank is targeting the exchange rate. However, concern about the level of the exchange rate is a short-term tactic that should be seen as part of an overall strategy for attaining the desired level of monetary conditions.[1]

Given the effect of disorderly markets on the conduct of monetary policy under floating rates, the authors may want to consider isolating and eliminating "crisis periods" from their sample.[2]

Is the Exchange Rate a Natural Stabilizer?

The authors present data that show that commodity prices in local currency are more volatile than the exchange rate. The implication is that "fear of floating" leads to exchange rate stabilization and the inability of the exchange rate to perform its role as a shock absorber.

To achieve macroeconomic balance in an economy that produces commodities, the effect on GDP of a commodity price increase (decrease) should be offset by the effect of an appreciation (depreciation) of the exchange rate. However, there is no reason to expect the volatility of commodity prices and the exchange rate to be the same.

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[1] There are also circumstances when confidence could be enhanced by floating. This appears to be what happened in Brazil in early 1999. When the *real* was floated and depreciated significantly, spreads on Brazilian debt tightened and the stock market rallied, reflecting the perception that fundamentals had improved.

[2] In "normal" times, volatile interest rates could be consistent with the low degree of monetization of emerging-market countries and a relatively low coefficient on interest rates in their IS curves. In such cases, large interest rate changes, relative to industrial countries, may be needed to elicit the desired response of aggregate demand.

At the Bank of Canada, IS curves have been estimated that include foreign GDP growth and the growth of real commodity prices as well as interest rates and exchange rates.[3] The estimated effect of a 10 per cent increase in the price of commodities would ultimately be a 0.7 per cent increase in the growth of real GDP. In addition, our exchange rate model predicts that the same commodity price increase would lead to an appreciation of the Canadian dollar of 4.8 per cent.[4] According to our IS-curve estimates, an appreciation of this magnitude would reduce the growth rate of GDP by 0.7 per cent, fully offsetting the effect of the commodity price increase.

The Policy Implication of Contractionary Devaluations

Commentators on Latin America have noted that if the monetary authority lacks credibility, the prospect of future inflation will make it difficult to find lenders willing to negotiate debt contracts in domestic currency. This will give rise to liability dollarization. If the country has a sufficiently large stock of dollar-denominated liabilities, then devaluations can be contractionary, since the rate at which debt grows, in local currency terms, would outstrip the country's ability to generate foreign exchange with which to service the debt.

If a country has reached this point, then an explosive dynamic is put into motion, which can threaten current account sustainability. Consider a negative terms-of-trade shock that affects the country's key export under floating rates. This would reduce the current account balance. While a devaluation would generate some foreign exchange, by assumption, this would be insufficient to offset the increase in debt service costs. Thus, the current account balance declines again. If the country has a significant amount of short-term liabilities, then the current account could be subject to a third negative shock if its risk premium rises.

If a country has reached the point where devaluations are contractionary, the economy would have the following characteristics: its tradable sector would be relatively small, or import and export demand would be relatively insensitive to changes in the exchange rate and the level of debt would be high.

It is clear that such a currency mismatch makes this type of national balance sheet very fragile, and it provides a rationale for the authorities to resist devaluations. However, as long as the authorities persist in exchange rate stabilization, incentives to accumulate dollar liabilities will remain, thus exacerbating the problem. Such a state of affairs is not sustainable.

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[3] See Duguay (1994) and Clinton (2000).

[4] The exchange rate model used here is described in Amano and van Norden (1993). The parameter estimate is taken from a regression run over the period 1973Q1 to 2000Q2.

One option for dealing with this problem would be full dollarization. This would rid the highly indebted country of the dangerous currency mismatch. However, other problems would remain. A negative terms-of-trade shock, in the first instance, would reduce the current account balance. Under fixed rates, the cost-of-debt service would not increase. However, a real depreciation would still be needed to restore macroeconomic balance. This would happen through a fall in domestic wages and prices and would require that output be kept below potential. The fall in output would further reduce the debt-servicing capacity of the country by increasing the ratio of the current account to GDP. The current account could be reduced in a third instance if the reduction in output affected aggregate supply such that the capacity to produce exportables was reduced. Finally, as in the floating-rate case, risk premiums could rise if the market believed that adjustment would take a sufficiently long time.[5]

Thus, it appears that when devaluations are contractionary, the sustainability of the current account is put at risk under both floating and dollarization. The policy implication is that, for such countries, the level of debt is unsustainably high and needs to be reduced.

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[5] If we assume that the tradable goods sector is small or that it lacks dynamism, it is reasonable to assume that macroeconomic balance will only be achieved slowly.

General Discussion

Commenting on the Calvo-Reinhart paper, Paul Masson considered their classification of monetary policy and exchange rate regimes rudimentary and thought it would be more useful to undertake a deeper examination of country experiences. In this way, he felt, they might be able to come up with a more insightful classification system.

Carmen Reinhart responded by stressing that she and Calvo were not reclassifying regimes but rather describing country practices. She agreed with Masson, however, that there is a whole gamut of gradations in exchange rate arrangements.

Michael Devereux noted that the choice of the bilateral exchange rate is important and he also stressed that many devaluations appear contractionary because the analysis fails to consider the original shock (e.g., a cessation of capital inflows) that leads to both a drop in demand and a depreciation of the currency. The paper assumes full pass-through of exchange rate changes into domestic prices, but is this always the case? Finally, he remarked that the title of the paper should be changed from the "Fear of Floating" to the "Fear of Sinking."

Reinhart agreed that the choice of the bilateral rate is important, but disagreed that they were ignoring the original shock.

David Laidler argued that a fixed exchange rate virtually defines a monetary policy regime, as does a crawling peg. A floating exchange rate, however, does not define a regime and, consequently, it is foolish to compare floating rates with fixed ones. Laidler stated that it is time to make a more profound and complete comparison of monetary regimes.

Linda Goldberg concurred with Laidler, but Reinhart disagreed, because she felt it was difficult to make such distinctions.

Paul Masson said that the IMF has, in fact, developed a new classification that specifically asks countries to clarify the monetary policy that underlies their flexible exchange rate regime.

With respect to the Bailliu, Lafrance, and Perrault paper, Michael Bordo offered an alternative explanation for their threshold effects that links floating exchange rates to growth via open capital markets and financial development. Historically, countries interested in attracting foreign investment tied their currency to that of a rich economy. Currently, most industrialized countries have a floating regime. Thus, an emerging-market country can either peg to an industrialized country, in which case it must absorb the shocks resulting from being on a peg, or it can float if it obtains the necessary level of financial development credibility. Jeannine Bailliu agreed, but added that they were careful not to draw too many causal links, since they did not address the endogeneity issue.

Nicholas Rowe divided the world into sensible countries and basket cases (i.e., those with unreasonably high rates of inflation). Sensible countries will either choose a fixed exchange rate or a flexible exchange rate with a nominal anchor. For the basket cases, flexible regimes are dangerously unmanageable. Rowe thought that the Bailliu, Lafrance, and Perrault results are biased to the detriment of flexible exchange rate regimes, because the study does not distinguish between the two types of countries on flexible exchange rates.

Bailliu and Reinhart agreed that such a distinction would be useful. The sample of emerging-market countries with sensible flexible exchange rate regimes, however, is relatively small.

In response to Rowe's comments, Robert Lafrance stated that the distinction is really between high-inflation and low-inflation countries. Making such a distinction could be done, but he noted that including the rate of inflation as an explanatory variable in the regression did not significantly alter the results.

Charles Freedman questioned the Calvo and Reinhart data, which indicate that New Zealand has intervened when, in fact, it has not. He pointed out that other factors can lead to reserve changes.

On the issue of commodity prices and a flexible exchange rate, Freedman noted that empirical research for Canada indicates that a 15 per cent decline in commodity prices is matched by roughly a 5 per cent depreciation in the real exchange rate. Thus, the Canadian flexible exchange rate acts as a shock absorber, not by protecting commodity producers primarily, but by expanding other exports.

He also remarked that movements in a flexible exchange rate have an impact on the real economy and on inflation. A monetary policy response to such movements may be warranted, depending on the source of the exchange rate change. Finally, while central banks may not have a target for the level of a flexible exchange rate, they may wish to avoid rapid and potentially destabilizing movements by adjusting monetary policy. Reinhart agreed with Freedman's observations.

Chris Ragan asked Reinhart to what extent they were able to distinguish between the fear of floating and the fear of exchange-rate-induced inflation. He also asked whether they had observed a higher degree of fear among floating regimes that do not have a credible nominal anchor.

Reinhart responded that this indeed appeared to be the case, since fear of floating is more concentrated in the emerging markets, most of which have had chronically high rates of inflation.

Panel Discussion

Discussion 1

Michael D. Bordo

Alternating Exchange Rate Regimes: The Canadian Experience, 1820–2000

Introduction

Canadian exchange rate history over the past two centuries displays an alternating pattern of fixed and floating rates. From the early 19th century until the mid-20th, fixed exchange rates generally prevailed. Since 1950, the opposite has been the case. My remarks will focus on the determinants of Canada's choice of exchange rate under different international monetary regimes.

I define a monetary regime as a set of monetary arrangements and institutions accompanied by a set of expectations—expectations by the public with respect to policy-makers' actions and expectations by policy-makers about public response to their actions. Two types of monetary regimes have been followed: one based on convertibility into a commodity, generally specie, and the other based on fiat.

The international aspect of a regime relates to the monetary arrangements between nations. Two basic types of international regimes have been pursued—fixed and flexible rates, along with a number of intermediate variants, including adjustable pegs and managed floating (Bordo and Schwartz 1999).

I argue that a key factor in Canada's choice of exchange rate regime was the international monetary arrangement prevailing at the time—convertible or fiat. This choice can also be understood in terms of rules versus discretion.

I define a rule as a commitment mechanism to prevent monetary authorities from setting policies sequentially in a time-inconsistent manner (i.e., by discretion).

Over most of the first century of our survey, Canada followed the gold (specie) standard convertibility rule, as did most other countries. The rule for the monetary authorities was to ensure that domestic currency was convertible into gold (specie) at a fixed price. Following such a rule left little room for activist monetary or fiscal policy. In countries that had central banks, the operating procedure or rule of thumb was to follow the "rules of the game"—to expand or contract the domestic monetary base depending on the level of gold reserves. A key implication of adhering to the gold (specie) convertibility rule for a small open economy is that the domestic price level was determined by prices in the rest of the world. It also meant that shocks and business cycle disturbances could easily be transmitted from abroad to the domestic economy.

The gold (specie) convertibility rule followed by many countries was a contingent rule (Bordo and Kydland 1995). It was contingent in the sense that the monetary authorities would keep the price of currency fixed in terms of gold—except in the event of a well-understood emergency such as a war, a financial crisis, or an external shock such as a decline in the terms of trade. Under these circumstances, the monetary authorities could temporarily abandon the convertibility rule, allow the exchange rate to float, and exercise monetary independence. In the case of a wartime emergency, for example, the monetary authority could issue fiat money to capture seigniorage revenue. The rule was contingent in the sense that the public understood that the suspension would last only for the duration of the emergency, and that the government would later adopt the deflationary policies necessary to resume payments at the original parity. Moreover, adherence to the rule would be viewed as credible to the extent that the original parity was restored.

I argue that Canada followed the gold convertibility contingent rule in various guises until the 1970s. Gold parity was maintained except in the face of financial crises in the 19th century, the two world wars, and the shock of the Great Depression. Moreover, under the post-war Bretton Woods system, with its indirect link to gold, the rule (although different in the sense that changes in parity were allowed under conditions of fundamental disequilibrium) was followed, and the contingency or "escape clause" was exercised from 1950 to 1962 and again in 1970. A major sea change occurred in the international monetary regime with the breakdown of the convertibility regime in 1971 and the adoption by major nations of managed floating. This development meant that there was no longer a convertibility rule to turn to, or put another way, there was no longer a nominal anchor defined in terms of gold (Redish 1996). The subsequent experience of Canada, the United States, and other major countries, was characterized by expansionary monetary policy in the 1970s that could possibly play the Phillips-curve trade-off and accommodate oil price shocks. The arrangement changed to a fiat regime based on discretion. In the 1980s, in response to the costs of high inflation, monetary authorities in Canada and elsewhere vigorously pursued a disinflationary policy, and by 1990, began explicit inflation targeting. This change in policy can be viewed as a new type of domestic policy rule—the domestic convertibility principle.

1 The History

1.1 The gold standard, 1820–1914

Before Confederation in 1867, Canada had no central bank, and the monetary role of the government was to define the gold content of coins acceptable as legal tender. Bank notes issued by chartered banks were required to be convertible into gold. The contingent rule in the form of a suspension of convertibility was exercised in the face of a financial crisis in 1837. In the crises of 1847 and 1857, authorities may have issued short-term debentures but did not suspend convertibility (Bordo, Redish, and Shearer 1999).

With Confederation in 1867, the Canadian government issued Dominion notes convertible into gold. The rule followed was based on the British Bank Charter Act of 1844 of a fixed fiduciary issue and an additional issue determined by gold reserves. The rule followed after Confederation was also contingent. In the face of the 1907 crisis, an emergency discount window was set up by the Department of Finance to provide Dominion notes to banks under liquidity pressure.

1.2 Wars and depression

In World War I, the escape clause was quickly invoked, and the currency became inconvertible. Through the institution of the Finance Act of 1914, which provided a liberal discount facility, Canada, like other belligerents, pursued an expansionary monetary policy, and this led to rapid inflation. After the war, Canada followed the British example and deflated in an attempt to restore the pre-war gold parity. This was achieved in July 1926. But the gold standard to which Canada had returned was a feeble variant of its predecessors. Weakened by problems, the gold standard had become vulnerable: key members had returned to gold at inappropriate parities, and members were no longer prepared to strictly follow the dictates of the convertibility rule and eschew activist financial policies for domestic goals. It lasted only six years. In the Canadian case, adherence to the convertibility rule was weakened by continued access by the chartered banks—after the war ended—to the discount window of the Finance Act.

In the face of external shocks, Canada de facto suspended convertibility in December 1928. However, expansionary monetary policy was not pursued, Canadian prices and output moved in line with those in the United States (see Table 1 and Figures 1 and 2), and Canada, in effect, shadowed the gold standard. In 1931, following Britain's departure from gold, the suspension of convertibility became de jure. The Canadian dollar floated halfway between sterling and the U.S. dollar until the United States left the gold standard in April 1933, and the Canadian dollar moved close to parity with the U.S. dollar (see Figure 3) (Bordo and Redish 1990).

Although the gold standard had been formally suspended in the 1930s, and a central bank, the Bank of Canada—was established in 1935, the floating exchange rate and effective abandonment of the gold standard were not used to run an expansionary monetary policy. Indeed, there is considerable anecdotal evidence to suggest that many in Canada expected the resumption of a form of the gold standard (Bordo and Redish 1987). Thus, the gold standard contingent rule was still in play.

World War II, like World War I, was largely financed by taxes and bond issues, with only a small fraction financed by monetary expansion. Although monetary expansion was significant, inflation was largely suppressed by vigorous controls.

1.2.1 Bretton Woods

After World War II, Canada became a charter member of the International Monetary Fund (IMF) and declared its parity in 1946 at US$1.

This rate proved to be too high and led to large balance of payments deficits in the next three years. Canada, along with the United Kingdom and many other countries, devalued its currency to 90.9 cents US in November 1949. With the onset of the Korean War, massive capital flows into Canada led to large payments surpluses and, hence, inflationary pressures.

Canada once again invoked the escape clause from the prevailing successor to the gold standard rule, Article VIII convertibility, and allowed the dollar to float in June 1950. As in earlier episodes, the float was viewed as a temporary measure until market forces determined a sustainable new parity.

Canada experienced few difficulties with the floating rate, and despite repeated criticism by the IMF and other authorities, persisted with it. The

Table 1
Inflation (CPI) and real GDP growth
Canada and the United States, 1880–1997 (percentages)

	Canada				United States			
	Inflation		Real GDP growth		Inflation		Real GDP growth	
Period	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
1880–1913	0.71	3.93	4.75	5.14	0.09	2.10	4.32	6.39
1925–1931	–1.22	3.94	2.17	7.72	–1.5	3.63	0.39	6.95
1932–1939	–0.79	4.11	3.44	7.73	–1.03	4.79	3.84	9.58
1950–1962	2.11	2.76	5.36	3.66	1.88	2.07	4.38	3.40
1963–1970	3.14	1.02	5.78	1.68	3.18	1.82	4.09	2.39
1971–1987	7.45	3.02	3.68	3.31	6.57	3.39	2.55	3.30
1988–1997	2.83	1.85	1.88	3.03	3.51	1.03	2.04	1.55

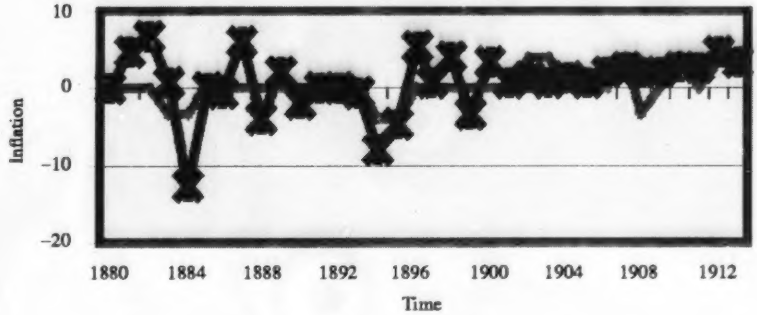
Canadian exchange rate remained remarkably stable, staying within about 6 per cent of par: it was almost as if Canada had continued the Bretton Woods par rate of exchange with a wider band of permissible fluctuation (Figure 3). Furthermore, it was a relatively "clean" float, since the Bank of Canada only intervened in the foreign exchange market to offset disorderly market conditions (Yeager 1976). Indeed, Canadian prices and output closely matched those of the United States (see Figures 1 and 2).

Canada declared a new Bretton Woods parity of 92.5 cents US in May 1962 under pressure from the IMF, but also after the government unsuccessfully attempted to talk the dollar down. The 1962 peg ran into immediate difficulties. A full-scale speculative attack on the Canadian dollar was only repulsed by a rescue package of over US$1 billion, the institution of (temporary) current account controls, and tight monetary and fiscal policies.

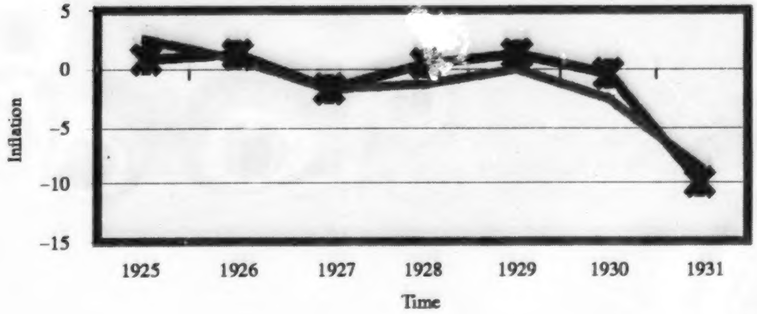
Canada maintained its peg at 92.5 cents US for the next eight years. The experience with pegged rates was initially successful because Canadian monetary and fiscal policies were compatible with those in the United States. Canada seemed to have avoided the policy dilemma posited by Robert Mundell (1968) between a pegged exchange rate, monetary policy independence, and free capital mobility. The early to mid-1960s was a period of rapid growth and low inflation (see Table 1 and Figures 1 and 2). As in the past, an external shock led to the evocation of the contingent rule and a move to floating exchange rates. In June 1970, as in 1950, Canada abandoned its pegged exchange rate in the face of massive capital inflows from the United States. The pressure, it is believed, resulted from expansionary U.S. monetary and fiscal policy to finance new social programs and the war in Vietnam. This policy led to growing balance of payments surpluses in Canada.

Figure 1
Inflation in Canada and the United States, 1880–1997

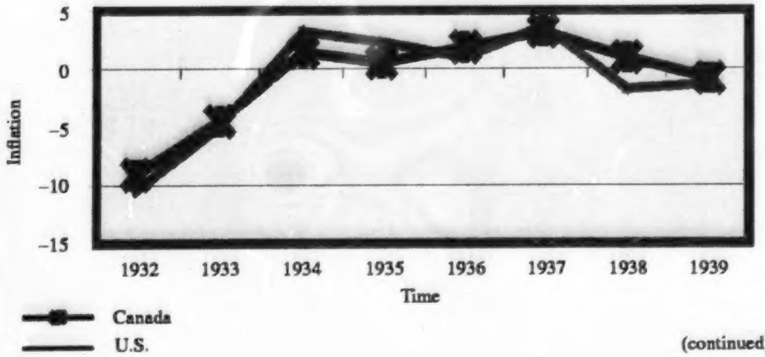
Inflation: 1880–1913



Inflation: 1925–1931



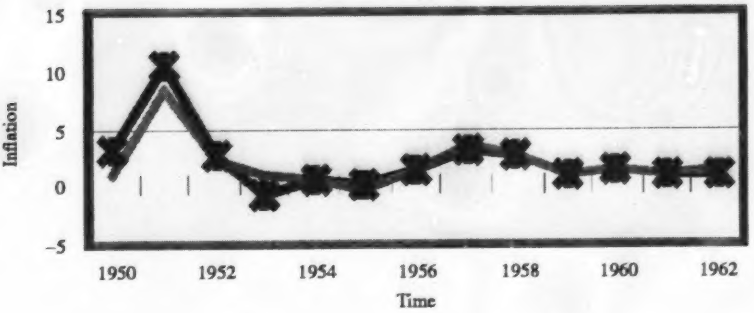
Inflation: 1932–1939



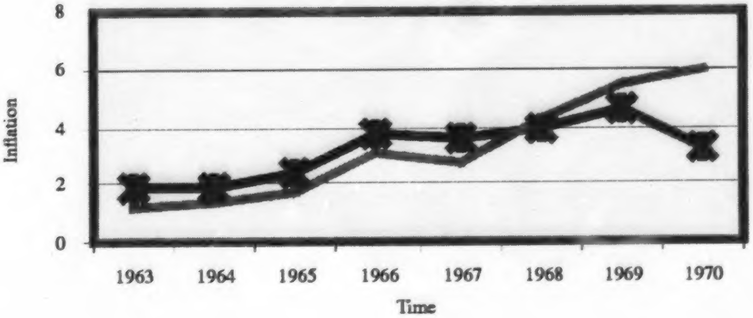
(continued)

Figure 1 (continued)
Inflation in Canada and the United States, 1880–1997

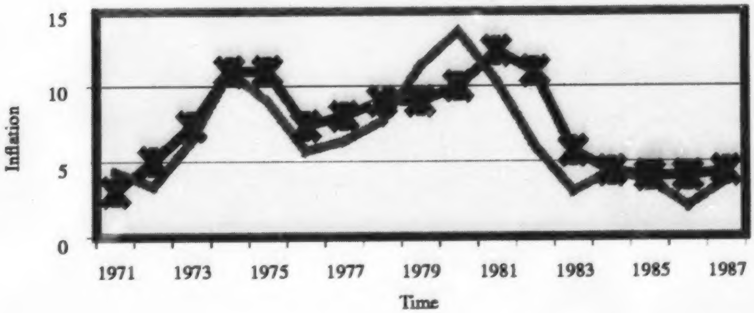
Inflation: 1950–1962



Inflation: 1963–1970



Inflation: 1971–1987



(continued)

Figure 1 (continued)
Inflation in Canada and the United States, 1880–1997

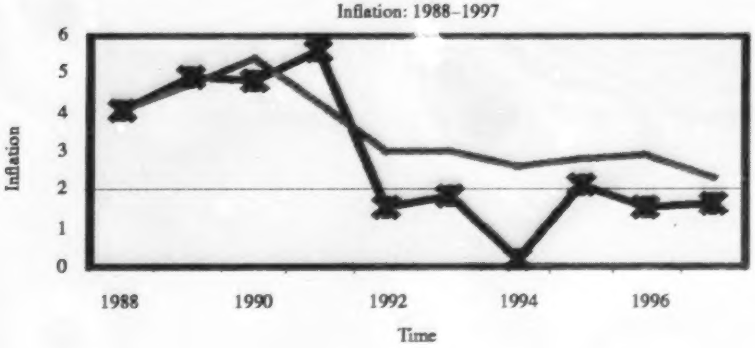
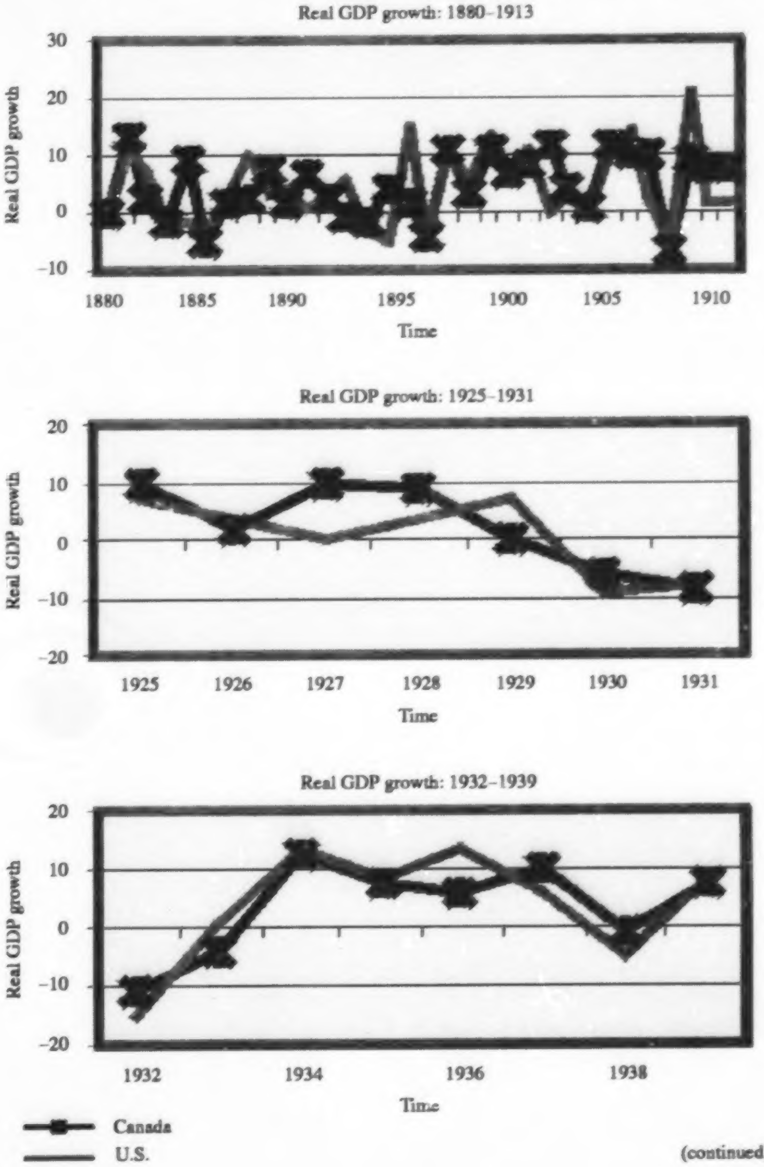


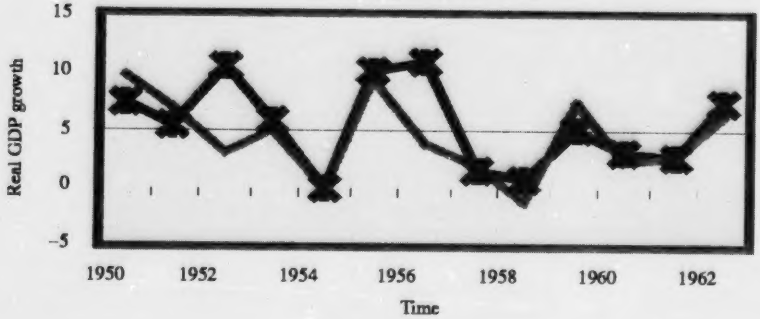
Figure 2
Real GDP growth in Canada and in the United States, 1880–1997



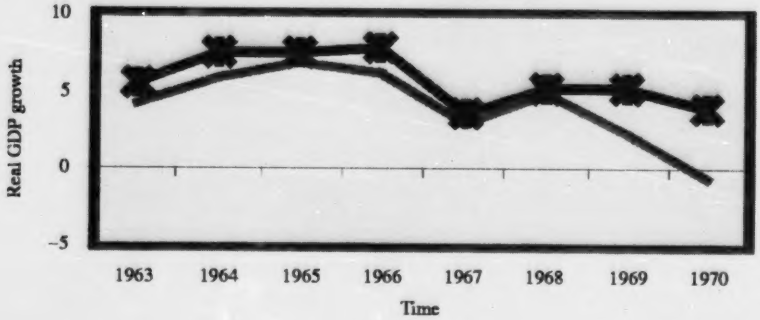
(continued)

Figure 2 (continued)
Real GDP growth in Canada and in the United States, 1880–1997

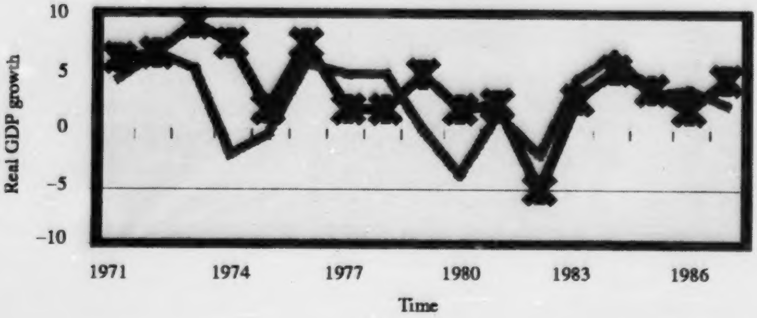
Real GDP growth: 1950–1962



Real GDP growth: 1963–1970

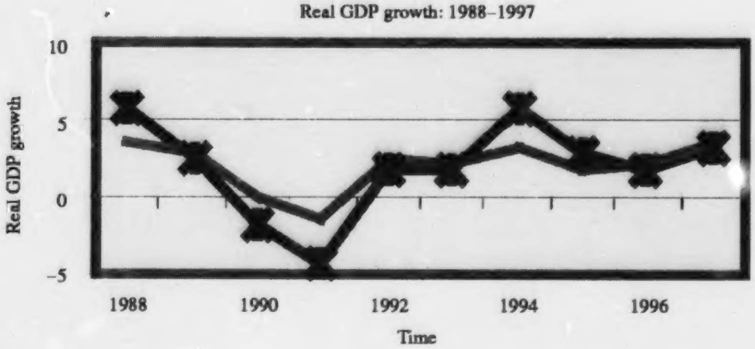


Real GDP growth: 1971–1987



(continued)

Figure 2 (continued)
Real GDP growth in Canada and in the United States, 1880–1997



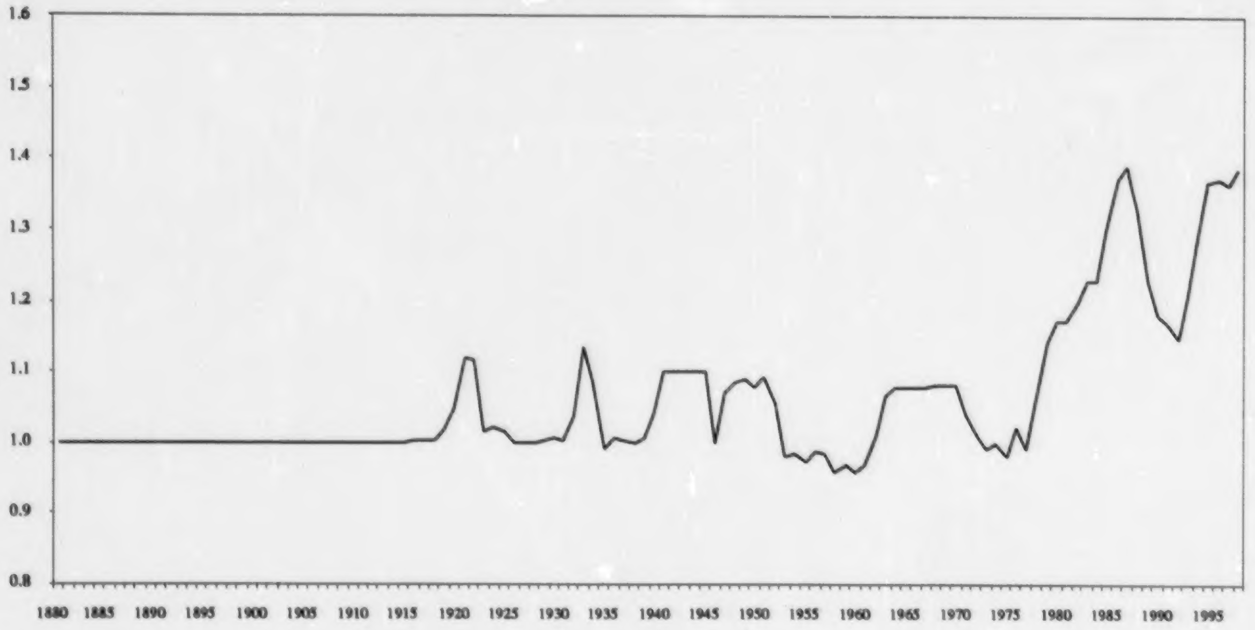


Figure 3
Price of U.S. $1 in Canadian dollars, 1880–1997

1.2.2 Managed floating

Canada's abandonment of its Bretton Woods parity in 1970 presaged the abandonment of pegged rates by all the other advanced countries in the following year. And the Smithsonian Agreement of 1973 permanently ended the adjustable peg of the Bretton Woods system. The abandonment of pegged exchange rates gave countries monetary independence. It also meant that there was no longer a nominal anchor to return to and, consequently, the regime changed from one based on a contingent convertibility rule to one based on domestic discretion. In this environment, Canada behaved no worse than the United States and other countries, but it did follow expansionary monetary and fiscal policies that led to unprecedented peacetime inflation (see Table 1 and Figure 1). The reasons for the Great Inflation of the 1970s are still debated, but the main candidates are the belief in the Phillips curve, accommodation of the oil-price shocks of 1973 and 1979, the financing of expensive social programs, the pursuit of incorrect monetary policy indicators, and incorrect measurement of output gaps.

From 1979 to 1981, the United States, the United Kingdom, and Canada reacted to perceived economic and social costs of high inflation by strongly pursuing disinflationary policies. These policies produced a serious recession and led to a return of lower inflation by the mid-1980s. In 1991, Canada began explicitly targeting low inflation and has been very successful at virtually eliminating inflation. In many respects, the adoption of low inflation as the prime target of monetary policy is a domestic fiat money rule that evokes the convertibility principle that prevailed under the gold standard.

Conclusion

Canada's choice of exchange rate has been determined largely by the prevailing international monetary regime and by the special external pressure it has faced because of its openness.

Consequently, the contingency aspect of the convertibility rule was often invoked by Canada, yet it largely followed policies that didn't dramatically differ from those of the United States and other countries, which adhered more closely to the rule. Until the 1970s, Canada used the monetary policy independence afforded by the contingent rule wisely. In the past decade, it has returned to its earlier record now based on a domestic convertibility-like rule. But should this state of affairs continue?

The recent experience with financial crises in an environment of growing financial market integration has led many writers to stress the advantages of bipolar exchange rate arrangements—currency boards and currency unions on the one hand or floating on the other. This raises the question whether Canada should stick with its managed float or, following the example of Europe, enter a currency union (with the United States).

The argument in favour of a currency union is that the elimination of exchange rate volatility and transactions costs increases international trade and, hence, real growth. The case for floating is still monetary independence in the face of external shocks. Recent empirical work surveyed by Frankel (1999) suggests that the balance may have shifted in favour of currency unions. This conclusion reflects his (and Andrew Rose's) evidence linking currency unions with dramatic increases in international trade and real growth, and increased cross-border correlation of output shocks, which reduces the case for monetary independence.

The lesson learned from my survey of Canada's exchange rate experience, however, suggests that moving to a currency union is in many respects like returning to the gold standard. Would it be like a contingent rule? Would the likelihood of external shocks, such as bad U.S. monetary policy, be sufficiently unusual to justify such an innovation?

This discussion has not considered the political aspects of currency unions, which have been closely intertwined with political integration. Indeed, the historical evidence suggests that successful currency unions generally occurred along with considerable political integration (Bordo and Jonung 1999).

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Discussion 2

Richard G. Lipsey

I want to make five general points suggested by our discussions over the last day and a half. They are not all meant as criticisms of the papers, since some of my points were covered quite well in several of the studies; others, however, were not. I accept what David Laidler said from the floor about the proper contrast being between various monetary rather than various exchange rate regimes, but I will still cast my comments in terms of exchange rate regimes, since they were the focus of the conference.

Feasible Alternatives Need to Be Specified

One question that is relevant for the policy debate and that has not been touched on here, is what kinds of fixed-rate regimes are practical alternatives to the present one? I see the current regime of flexible rates with inflation (or price-level) targeting at one extreme and a monetary union with the United States at the other. Both of these are technically feasible, although there are strong doubts that the latter would be politically acceptable to either country in the near future. Is there an alternative intermediate regime that would be acceptable and feasible? To be acceptable, it would have to be a pretty hard-pegged rate with little expectation of periodical adjustment.

I would argue that this regime is not feasible given the Canadian-U.S. circumstances. First, Canada has large, periodic terms-of-trade shocks coming from the resources sector and large and variable capital flows, resulting in an exchange rate that has varied from about $0.95 to $1.55 over that last 35 years. Consider, for example, what would have happened if the Bank had decided to peg the rate early in the 1990s when it passed through the purchasing-power-parity point of about $1.25. Does anyone believe that that rate could have been held until now when the market equilibrium rate has been fluctuating between about $1.45 and $1.55? As the author of one of the papers presented yesterday observed, very few countries have managed to hold a pegged rate unchanged for as long as 50 years.

Second, there are limitations on tools for stabilizing the rate that did not exist in the Bretton Woods period. To mention just one example, foreign exchange controls on both current- and capital-account transactions of the sort routinely imposed by many countries under the Bretton Woods system, and by many smaller countries today, would be unacceptable in Canada today—and probably impossible to enforce in any case.

Third, there is a political problem. To illustrate, let there be a large shock that required a marked increase in the interest rate to stabilize a pegged Canadian dollar. And let this take place close to the time of an election. The high interest rate would surely become an election issue. The market would then wonder: if the election is won by the opposition, will they stand by promises to drive down interest rates and accept the devaluation that will inevitably follow?

Fourth, destabilizing speculations would be a continuing problem for the Bank. If, for any of the above reasons, it is believed that the rate may occasionally need to be altered, the market will be testing the Bank whenever the currency comes under pressure to determine whether this is the run that cannot be resisted. As James Meade argued long ago (I think before Milton Friedman began making the same point), speculation is destabilizing under an adjustable peg, because the bets are all one way—either the rate is held, or it is changed in a direction that is known to everyone. All of these considerations lead me to the conclusion that the only realistic choice facing the Bank today is between the existing regime of flexible rates and a monetary union with the United States.

John Helliwell pointed out that the papers in the session on emerging markets showed that many countries do adopt some middle ground between fluctuating rates and currency unions. Whereas many had pegged rates in the past, today they more often announce that they are on a flexible rate and then engage in substantial stabilizing actions. These actions sometimes produce what looks like a fully pegged rate, except for the absence of a commitment to defend a specified rate under all circumstances. While this kind of "very dirty float" is clearly a feasible alternative, at least over the short and intermediate terms, it is probably not what the critics of the Bank's present regime have in mind. They appear to advocate either a currency union with the United States or a traditional pegged rate, with the Bank committed to defending a publicly announced par value for the Canadian dollar.

Whether I am right or wrong in my view that there are only two possible regimes that the Bank of Canada can realistically choose from, this is a topic that needs full consideration whenever the debate touches on the shortcomings of the present regime. The critics need to specify, and defend the feasibility of, the alternative that they are advocating. If they believe that the Bank could sustain a pegged rate, they should argue their case in some detail and not just point out the shortcomings of the present regime. This has even more force if, by any chance, they are considering a quasi-fixed rate under a regime of "very dirty float," which is currently found in many emerging countries, particularly in Southeast Asia.

Useful Criticisms Are Comparative

Assessing the significance of calculations of the costs of the present regime requires comparing them with the costs of a proposed alternative regime. That exchange rate fluctuations impose some costs under the current regime is undeniable; only their magnitude is uncertain. The true net cost of the present regime, however, is its costs *minus* the costs that would be incurred under the proposed alternative.

If the alternative is the politically feasible pegged rate, there are at least two major sets of costs that need to be put into the balance. The first is the short-term interest rate fluctuations required under such a regime. After all, interest rate fluctuations have always been a major tool for stabilizing the exchange rate in the face of short-term fluctuations in the demand for, and supply of, foreign exchange. (It is almost always true in economics that the cost of policy-induced reductions in the fluctuations of one economic variable is larger fluctuations in some other variable(s)—a simple illustration of the no-free-lunch proposition.) A second set of significant costs are those associated with the change in the pegged rate when such adjustment is forced on the Bank—as I have argued that sooner or later it would be. We heard in the paper by Bailliu, Lafrance, and Perrault that the crises associated with the devaluations under fixed rates also seem to be associated with slowdowns in growth rates. (Although it is difficult to say how much of this is due to the fixed rate itself and how much to the other causes of the crisis that would have existed even if the rate had been fluctuating.) When we are dealing with moderate fluctuations, the alternative is clear: the fluctuations would not exist under a pegged rate whenever the rate was sustained. But what about the larger fluctuations that have taken our rate from about $1.12 to the vicinity of $1.50 in less than a decade? As I have already asked, could the rate have been held through to today if it had been pegged at $1.25? If not, it is misleading to imply that the calculated costs of the observed rate fluctuations *are* the costs of the present regime.

If one has a pegged rate in mind, as many of the current critics seem to do, then the costs under that regime must be estimated and set against the costs under the present one. Most of the costs of the pegged rate would not, however, exist under a currency union. It is misleading, therefore, to treat the gross costs of a fluctuating rate as net costs unless one is advocating the currency-union alternative. If one has such a union in mind, it must be admitted that this is a very long-term goal not politically feasible in the near future.

Understanding the Bank's Exchange Rate Equation

The Bank's equation for explaining the exchange rate is remarkable indeed. (See the fascinating paper by Djoudad et al.) But one thing worries me about it. This concern was sparked by John Helliwell's explanation—which I think is correct—of the perverse sign on the energy-price coefficient in the Bank's equation. You will recall that John argued that our being a high user of energy could not explain the perverse sign on the energy coefficient as long as we are a net exporter of energy, and that the real explanation has nothing to do with Canada. When there is a major energy-price shock, his argument continues, there is a "rush to quality" in the market as investors worldwide scramble to buy U.S. assets—for reasons that are not fully understood. This causes the U.S. dollar to appreciate and the Canadian dollar to depreciate for reasons unrelated to events in the Canadian economy.

More generally, Canadians are so self-centred that we almost invariably take a depreciation of our dollar as requiring a Canadian explanation, whether it is a Canadian depreciation or an appreciation of the U.S. dollar, for reasons that have nothing to do with Canada.

What has this to do with the Bank's equation? Well, what bothers me is that it seems to use Canadian variables to explain movements in the bilateral exchange rate, both when they emanate from causes that affect Canada and when they do not—such as a major run on the U.S. dollar or a major rush of capital into the United States.

If the Fed pushes U.S. rates down, or the Bank of Canada pushes them up, that should, according to the equation, cause the Canadian dollar to appreciate. That is all well and good. But let there be a rush to move capital into the United States for reasons unrelated to Canada. That should lead to an appreciation of the U.S. dollar and force U.S. asset prices up and U.S. yields down. The result should be a depreciating Canadian dollar combined with a rise in Canadian interest rates relative to the United States. In the case of energy prices, we have the Helliwell hypothesis: the energy coefficient is taking the blame for what should be a "perverse" relationship between the interest differential and the bilateral exchange rate. But what about other cases in which external value of the U.S. dollar changes for reasons that do not affect on the Canadian economy. Why does the Bank's equation do so well in these circumstances? (Or perhaps this is an explanation of the times when the equation does not perform so well?)

Flexible Rates Are Best for Canada

The consensus at this conference seems to be that flexible rates do a pretty good job for Canada without incurring dramatic costs. Andrew Rose's evidence, however, appears somewhat at odds with this. I find it compelling and would not quarrel with the conclusion that currency unions do have some significant effects in expanding trade. One part of the explanation of the gravity model's mystery of "too much" domestic trade may concern different currencies. (People can be irrational about currencies. For example, even some of my most rational U.S. economist friends insist on using U.S. dollars when they come to Canada, even though retail outlets give them a very poor exchange rate. I am never quite sure why, but there seems to be some kind of gut feeling that their money ought to be acceptable here. Try as I may, I can seldom get them to a bank to change their currency at the correct rate.)

Nonetheless, I would suggest some caveats to Rose's figures before extending his results to other countries.

- All of the countries on his list are, as he himself points out, either small or poor, and many are or were, dependent on some larger country. The fact that, as he repeatedly emphasized, decisions to form a currency union are made on political grounds does *not* demonstrate that economic conditions are unimportant. Let the set A be those whose economic conditions make a currency union desirable. Let a proper subset of A be chosen on political grounds. Now, all unions come about because of political decisions, but economic considerations have still mattered in determining the set from which the politicians can choose elements. I do not know if this is true. I only make the logical point that because the choices were made on political grounds does not preclude the possibility that certain economic conditions also had to be satisfied.
- Many of the countries on Rose's list were colonies or were otherwise dependent on one large country, the relationship being one central and several peripheral countries. A revealing calculation would be to eliminate the trade between the peripheral countries and the central country and see how much trade there was between the peripheral

members of one union—for example, the former French colonies with one another, but not with metropolitan France.

- It is a big step from more trade to more growth. I have no doubt that fully or mainly closed economies have trouble growing in today's globalized world. A certain amount of openness is necessary to take part in global specialization. But it is less obvious that making an already highly open economy a little more open will add to its growth potential. In other words, is the relationship between more openness and growth continuous or merely a threshold requirement? If there is a continuous relationship, Canada should have undergone a spurt of growth when, as a result of the Canada-U.S. free trade area, Canada's trade/GDP percentage rose during the 1990s from the mid-20s to around 40 per cent.

Reinhart and Calvo raised the spectre of fear of fluctuating exchange rates. While I don't think that any advanced country needs to share this fear, I have no doubt that many small countries with large debts denominated in foreign currencies do fear a fluctuating rate, which probably means they also fear a depreciating one. (Or, as Mick Devereux said: "When my daughter says she fears swimming, she means she fears drowning.") Part of the problem for these countries lies in the false security given by a rate that was believed to be fixed but that could not, in fact, be defended in the long run. This encouraged the acquisition of foreign-denominated liabilities. Many small countries have no alternative but to acquire such obligations. Nonetheless, an exchange rate thought to be fixed but that is, in fact, adjustable, encourages an incorrect assessment of the exchange risks of such liabilities. If agents correctly assess the risks that the rate will be changed under pressure, they are acting *as if* the rate were fluctuating and, as a result, some of the alleged advantages of the fixed rate were no longer present.

Reinhart and Calvo also tried to estimate the kind of exchange rate regime in place by observing the variation in rates. This is similar to the old error of arguing that the observation of few differences in the prices quoted by various agents in some market is evidence of lack of competition and even of collusion. But as theory tells us, the closer a market is to perfect competition, the less dispersion of prices there should be in that market. Similarly, a fully flexible rate combined with good macro policies and a well-informed set of stabilizing speculators will produce an exchange rate that is relatively stable in the face of short-run shocks (but it will not prevent the rate from undergoing trend changes in the face of alterations in the fundamentals that determine the real rate). So, although it is not desirable to take at face value the kind of exchange rate regime that governments say they are following, it is not valid to use the variance of actual exchange rates to assess the degree of policy flexibility. Put another way, flexible rates refer to potential, not to actual changes in the rate.

Productivity and Technological Change

The paper by Bailliu, Lafrance, and Perrault makes an important contribution to the investigation of a possible relationship between exchange rate regimes and economic growth—although as Paul Masson cautioned in his comments, the jury must remain out on this issue for a while yet. In the meantime, the authors' conclusions seem eminently plausible. First, major upsets, which include forced devaluations, are likely to have slowing effects on investment and technological change that show up as temporary reductions in growth rates—which still leaves the question of whether the effects of these shocks will be enduring or only transitory. Second, the long-term growth rate is influenced by so many fundamental forces that determine the rate of technological change that I would be amazed if two reasonably well-managed regimes, one floating and the other fixed, would have any noticeable differential effects on long-term growth rates. I hold this expectation not because I believe in a complete separation of real from monetary forces in influencing long-term behaviour, but because I believe that the forces that determine technological change are too strong to be significantly influenced by the choice between two well-managed exchange rate regimes. The "well-managed" proviso is important. It is obvious to even casual observers that a government can mismanage an economy to the extent that growth rates are effectively driven to zero, or even to negative values, for long periods of time.

Rick Harris's paper is also an interesting contribution to this debate. Some of his data appear unsettling at first glance. In particular, the data for small firms seem almost too dramatic to be true. Many of these firms are in the new economy; others are in traditional areas, many of which are non-traded. It would be helpful to see a breakdown into sectors. If the poor figures hold up across the board, there would appear to be something wrong with them. My message here is that there does seem to be something disturbing going on, but there are too many possible explanations, such as poor data, to justify jumping to radical conclusions.

Finally, I'd like to say a few words about one of Harris's possible smoking guns, which raises an issue that emerged in many different papers. This relates to my own research on technological change. Neo-classical economics is an extremely valuable tool. Little more is needed to understand the behaviour of exchange rates, volumes of trade, and the response of capital investment to changes in relative prices of labour and machinery—to mention three things that arose many times at our conference. But where standard theory lets us down is in the behaviour that concerns Harris and the other authors who deal with long-term growth—technological change. Invention and innovation are different from most of the things we study in standard economics, because genuine uncertainty, not just risk, pervades the invention-innovation process. (I am using the Knightian distinction that the possible outcomes of risky situations can be expressed by some probability-density function, while the outcomes of uncertain situations cannot.) Economic analysis handles risk easily, since agents merely maximize expected values. When major technological advances are attempted, however, it is typically impossible even to enumerate in advance the possible outcomes of a particular line of research, let alone to attach a probability to each. For example, the search for one breakthrough often produces a breakthrough in an unexpected direction. Of course, most people who make decisions regarding R&D must form subjective expectations and revise these in a kind of Bayesian process as experience accumulates. This does not, however, alter the key characteristic of uncertain situations that *two equally well-informed agents, with the same objective function and presented with the same set of alternative actions, may make different choices—in contrast to risky situations where the two agents will make the same choice: the one that maximizes the expected value of the outcome.* If the choice concerns R&D, one agent may back one line of attack while the other backs a second line, even though both know the same things and both are searching for the same technological breakthrough. After the results are known, one agent may prove to have made a better decision than the other, but no one can say which agent is making the better choice at the time that the decisions are being made. This sort of thing happens all the time when firms are in competition for innovation. When striving for the next generation of breakthroughs, Japanese firms may make one R&D choice while U.S. firms make another, and only later do we know who made the better decision.

Because firms are making R&D choices under uncertainty, there is no unique line of behaviour that maximizes their expected profits—if there were, all equally well-informed competing firms would be seeking the same breakthrough made in the same way at the same time. Because of the absence of a unique best line of behaviour, firms are better seen as groping their way into an uncertain future in a purposeful and profit-seeking manner, rather than maximizing the expected value of future profits. This type of behaviour is best modelled in evolutionary rather than neo-classical models. In these models, agents struggle in a profit-seeking manner through a foggy environment in which they can at least partially anticipate the outcome of the next couple of steps, but they have little or no idea where the next sharp turn or hole in the road may be. The result is a path-dependent process that is highly sensitive to initial conditions and that, if repeated, would not necessarily result in the same outcome. In this kind of world, transitory shocks can have permanent effects, one result of which is that there is no guarantee that real and monetary variables will be sharply separated in their influences over any time horizon.

Note that Helpman and Lucas—to mention two authors referred to in this context during our proceedings— and all the others who argue that there is no long-term link between the real and monetary sectors, assume perfect foresight and/or that everything that is not perfectly known can be reduced to risk. My co-authors and I have written two chapters in Helpman's excellent book on general-purpose technologies (GPTs),[1] in which we point out that the pioneering attempts to theorize about this difficult issue assume a number of things that are contradicted by the facts. All of the models assume that when a new GPT arrives on the scene, it is recognized as such, which was clearly not the case with most GPTs that we have seen thus far. The models assume that the full course of the GPT's evolution is foreseen at the time of its original introduction. This is manifestly untrue, as will be shown, for example, by a moment's reflection on what the inventors of the first practical dynamo in 1887 could have foreseen about all of the new technologies that were made possible by electricity, right up to, and beyond, the beginning of the 21st century. My point is not to disparage these pioneering attempts to replace the modelling of technological change as some faceless homogenized shift in an assumed aggregate production function with more realistic structured views of technological change. Instead, my point is that what we know about technological change upsets our confidence in neo-classical propositions concerning the isolation of all real outcomes from monetary shocks over the time horizon in which technological change dominates the growth process, as it does over very long periods of time. Although the separation may be true for many real variables, it is suspect with respect to technological change.[2]

How Harris's suggestions, and those of Bailliu, Lafrance, and Perrault, will stand up, is an empirical matter. All I want to point out here is that neo-classical models with perfect foresight and risk-only, paint a picture that does not conform with much of the micro theory and evidence about the behaviour of firms in innovating situations. Theory and evidence exist for a path-dependent evolution of technological change that will be influenced by many forces both real and nominal, including the behaviour of the exchange rate. So we cannot rule out such possibilities a priori. Having said that, I will close with a reminder of what I said above—that I would be surprised if anything so fundamental as the path of technological change were significantly influenced by something so relatively trivial as the choice between two well-managed exchange rate regimes.

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[1] See Helpman (1998). This book includes many of the models to which I refer in the text and also two chapters by Lipsey, Bekar, and Carlaw: Chapter 2, "What Requires Explanation?" and Chapter 8, "The Consequences of Changes in GPTs."

[2] I have discussed these issues in a series of publications on theory and policy. See, for example, Lipsey (2000), Chapter 2, and Lipsey (2001).

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Discussion 3

John F. Helliwell

The Evidence on Key Issues

The relative ability of fixed and flexible rates to stabilize prices and output when the economy is subject to fluctuations

Several Bank papers (Macklem et al. in the GE stable, Djoudad, Gauthier, and St-Amant and Lafrance and Tessier with VARs) could be seen as a symphony of very professional studies aimed at improving modelling of the comparative ability of fixed and flexible exchange rates to aid in the digestion of shocks, especially those relating to the terms of trade. All of them tend to find systematic advantages for flexible over fixed exchange systems. Devereux's GE model produced the same result, although in discussion he described himself as being impressed by the high welfare gains seen to flow from the Macklem et al. model, much higher than his or most other previous results. The Macklem et al. estimates of the macroeconomic benefits were substantial enough to handily exceed estimates of savings in transactions costs likely to flow from the use of a common currency.

The costs and benefits of intervention under flexible exchange rates (Djoudad et al.)

The specification of the Bank's fundamentals model

There was widespread admiration for the longevity of the continued goodness of fit of the Bank equation and for its ability to track the Australian and

New Zealand dollars reasonably well. There was much skeptical discussion of the negative sign on the energy-price term in the Canadian and Australian equations. The arguments offered in support were not given much credence, as noted by Dick Lipsey in his comments. Canada's role as a major user of energy in other industries was not regarded as sufficient, since several of these industries, e.g., aluminum, are best seen as alternative ways of exporting Canadian energy. Thus, they would tend to increase, rather than decrease, the expectation that the Canadian dollar, like the U.K. pound and the Norwegian krone, would be seen as a petro currency. Moreover, the idea advanced in discussion—that the U.S. dollar might strengthen because the United States was more self-sufficient in oil and energy than Germany and Japan—provides no reason why the U.S. dollar should strengthen relative to even more energy-rich Canada. I suggest that the strength of the U.S. dollar, relative to all other industrial country currencies, was due to the position of U.S. financial markets as OPEC's first choice for investment, and to other surpluses generated by higher oil prices, combined with the frequent, although not always explicable, flight to the U.S. dollar in times of financial uncertainty. Since there are likely to have been changes in the link between energy-price increases and parallel investment movements favouring the U.S. dollar, it is perhaps not surprising that the coefficient on this variable has not been stable as the sample period changed.

Examination of the consequences of direct and monetary intervention

The Djoudad et al. paper estimated that chartist behaviour seemed prevalent in tranquil markets, with fundamentalists (presumed to be those betting according to the predictions of the Bank's equation) becoming dominant in turbulent times. They used this result to infer that exchange-rate-induced intervention was likely to be unnecessary and counterproductive.

In his discussion, Gregor Smith argued that the Bank equation could be used to provide some measure of the extent to which the exchange rate was influenced by monetary policy, and he recommended additional study of the timing and effects of official intervention and a closer analysis of the extent to which monetary policy was, in fact, determined by exchange rate considerations. I think he is right and that, in general, the sources and consequences of official support, both direct intervention and exchange-rate-focused interest rate changes, merit more research.

I suspect this would require—shades of exchange rate modelling at the Bank in the 1960s (e.g., Helliwell 1969)—separate estimation of official intervention, net private demand for foreign exchange, and a monetary policy reaction function. It would be excessively brave to expect to find much stability of structure, but the challenge posed by Smith is worthy of a serious research effort of the sort the Bank has long been noted for.

How dangerous is the middle ground?

Occupation of the middle ground, while unfashionable, is prevalent, as shown by Calvo and Reinhart[1] and by Bailliu et al. What is perhaps most risky is the weak peg; what is much more common, and much less risky, is a rusty flexible rate. No commitment need be, or should be, made to a specific rate, and the extent and nature of support can be altered without loss of credibility. The risks come, as much of the conference discussion showed, where there is no credible commitment to a nominal anchor. Such an anchor is more likely now than 15 years ago to be the inflation rate or the price level, rather than a monetary growth rate or a target of the money stock—and so much the better for that.

Is a monetary conditions index (MCI) a useful management tool for monetary policy under flexible exchange rates?

This issue, raised by Mark Kruger, is tightly linked to the question of whether, and in what way, it is appropriate for interest rates to be changed in response to exogenous changes in the exchange rate. An MCI approach would normally involve a rise in domestic interest rates to offset, at least partially, the impact on the MCI of an exogenous fall in the exchange rate—otherwise, there would be an unintended change in monetary conditions. This is equivalent to using interest rates to lean against the wind in response to exogenous exchange rate changes. Although this is a defensible strategy, it presumes some ability to sort out fundamental from non-fundamental changes in the exchange rate, and the strategy must always be conditional upon maintaining the credibility of the chosen nominal anchor.

The economic consequences of currency unions

This is a key issue raised by the stylized fact, discovered by Andy Rose, that members of a currency union trade three times as intensively with each other as do similarly placed non-members. When seen in conjunction with the research by Frankel and Rose (2000), who argued that greater trade leads to higher output, a case can be advanced that currency unions are good for GDP. The two parts of the case need to be considered separately: (i) the effects of a currency union on trade, and (ii) the effects of such increased trade on GDP and welfare.

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[1] This volume includes the paper by Carmen Reinhart entitled "The Mirage of Floating Exchange Rates," and not the Calvo and Reinhart paper, "The Fear of Floating," which was presented at the conference.

The effects on trade; or, who joins a currency union?

One way of interpreting the Rose paper is answering the question of whether the right countries have joined currency unions. He finds that they have. He is also inclined to infer that some of the characteristics that define these countries may have been brought about through the adoption of a common currency. This is especially true in the case of international trade, where Rose finds that currency-union members trade much more with each other than do countries that are not members of currency unions. In discussion, Rose argued that although the reverse causation was worthy of study, it was not likely to be empirically relevant. I am less sure of that and, hence, am even more keen to await the results of the euro experiment, and to applaud Denmark, on scientific grounds, for narrowly voting to stay out, thus joining the United Kingdom and Sweden in providing controls that will make the euro experiment as close as we get to a set of macroeconomic conditions that mimic the conditions required for a natural experiment to show the effects of a currency union.

I suspect that despite Rose's efforts to include variables that might result in both currency-union membership and expanded trade—e.g., common colonial histories and common languages—there are undoubtedly other factors and historical ties that link certain groups of countries, with expanded trade and currency-union membership as joint consequences of these common causes. To this extent, the finding of greater trade among currency-union members cannot be considered a measure of the trade effects of establishing a currency union. For this reason, as well as to provide evidence directly applicable to developed industrial countries, the euro experiment has a unique value. As emphasized by Rose, the border effects for trade require explanation, and their size is large enough to permit even a large common-currency effect to still be only a relatively small part of the total explanation.

The link from trade to output

In discussion, Rose mentioned the striking calculation in Frankel and Rose (2000), that joining a currency union with the United States would lead to an increase of 36 per cent in Canadian GDP. This calls for some investigation. The result is based on a two-step procedure, with a first stage estimating the link between currency-union membership and trade, and a second stage, based on cross-sectional GDP level equations, estimating the link between trade and output. The authors find a significant effect of trade on output, and are encouraged by the result that this effect is even stronger if actual trade is replaced by the basic gravity-model determinants of partner-country size and proximity. I think that the latter result, in fact, gives grounds for questioning the basis for the analysis. Earlier studies of the effect of trade on growth (including Leamer 1988 and Helliwell 1994) have argued that to find a measure of openness that reflects the effects of policy, one should use the extent to which actual trade flows differ from those that depend directly on the size and proximity of trading partners. Thus, what Frankel and Rose should be looking for is an effect of trade based on some measure of the extent to which trade differs from that predicted by the simple gravity model.

It would also be possible to separately consider the effects of the trade increase that would be predicted (from the trade equations estimated earlier) to follow from membership in a currency union. The fact that Frankel and Rose find that countries have higher GDP per capita if they are close to large and well-off neighbours is an interesting result in its own right, but it says nothing about the income effects of expanding trade, whether by currency unions or through other means. It is probably related to other results showing that knowledge spillovers, within countries or across borders, decline with greater distance (Keller 2000). Thus, it is to be expected that there are GDP-level and perhaps growth advantages to being located near major centres of knowledge creation. This is probably part of the reason why the smaller European countries can be at the same income levels as the larger countries. What still needs to be established is the extent to which knowledge spillovers are greater with tighter trade linkages as opposed to only size and proximity effects.

The Frankel and Rose indication—that the output effect of the gravity-model determinants is bigger than that of the trade flows themselves (as suggested by comparing their ordinary least squares and instrumental variables results)—leads one to suspect that there is a positive output effect for countries that are close to large neighbouring countries, with additional trade having a smaller effect, or perhaps none at all. A location close to large and knowledgeable neighbours could well have positive spillovers for growth and output. This could also be responsible for additional trade, without the trade itself being the cause of or the conduit for, the spillover. Only additional research can assess these effects, but in the meantime, it would be a mistake to use their current estimates of the output effects of currency unions.

The link from trade to welfare

To supplement fresh research results, there are several other types of evidence that can give us some idea of what GDP and welfare benefits are likely to flow from expanded trade. There are well-known results (e.g., Sachs and Warner 1995) suggesting that successful convergence for emerging economies is more likely if they are sufficiently open to goods, capital, and especially ideas, from the rest of the world. But is this relationship linear? How much openness is enough?

I first started to think seriously about this question after discovering the prevalence of border effects for trade, capital, and migration. The trade effects are so large, even among industrialized countries, as to imply that national economies are an order of magnitude more tightly woven internally than across national boundaries. If gains from additional trade are still substantial for these industrial countries, then border effects are likely to be damaging to welfare. What evidence might help to indicate if there is a basis for concern?

A first, easy test is to compare the levels of GDP per capita among the industrial countries. Given the size of border effects, large countries have much greater internal, and therefore dense, trade networks. If additional trade has significant advantages, then GDP per capita will be larger in the larger countries. Yet if one looks across the OECD economies, there is little systematic relationship between population and GDP per capita. The smaller countries do very well, which suggests that their existing international trading opportunities are sufficient to allow them to exploit major sources of comparative-advantage trade, to achieve adequate economies of scale and to gain access to international sources of knowledge.

Additional evidence is provided by the Canadian experience in the 1990s, during which there was a very large policy-induced increase in the density of two-way manufacturing trade with the United States, and yet no evidence of a narrowing of the aggregate productivity gap in manufacturing. The actual trade flows increased three times as much as was forecast in pre-FTA studies, while the effects on aggregate manufacturing productivity were far less than forecast.

Both of the above pieces of evidence suggest that increases in openness beyond those already existing among the industrial countries might not be expected to produce major gains in income and productivity. There is a third strand of evidence that speaks more directly, if somewhat imprecisely, to the welfare effects. There is now an increasing body of literature that uses subjective measures of well-being, whether to revisit estimates of the appropriate weights to attach to macroeconomic goals, or to assess the consequences of alternative forms of government (Frey and Stutzer 1999). Some results suggest diminishing welfare returns to increasing average per capita incomes, relative to other determinants of well-being, such as education. In addition, there is evidence that individuals value increased relative income much more than income increases that are received by all, while the reverse is the case for education, social capital, and probably health (Putnam 2001; Helliwell 2001a, 2001b).

Exchange rate regimes, productivity, and growth

Rick Harris outlined some of the theories advanced to explain why under- or overvalued exchange rates might be linked to temporary or permanent differences in the level or rate of growth of productivity. He argued that experiences of single countries were unlikely to provide convincing evidence, and presented some preliminary results from a panel-data set for OECD countries. His dynamic results, as worked out by David Longworth, suggested that a once-and-for-all depreciation in the real exchange rate, relative to general purchasing-power parity (PPP), would lead to an eventual reduction in the level of output per capita. He was inclined to treat this as evidence that the undervaluation of the Canadian dollar in the 1990s might, therefore, have contributed to the lower productivity levels during the decade. In discussion, the Harris results were criticized for using general PPP as a definition of the equilibrium rate, a criticism that Harris accepted in theory, while continuing to use general PPPs as the only widely available measure.

The distinction between resource and other prices is very important to interpreting the Harris results. Changes in resource prices are generally seen as a key fundamental for determining the relative value of the Canadian dollar. When resource prices weaken, some fraction of this weakening shows up in the external value of the Canadian dollar, in relation to the values that would be suggested by PPP for GDP. This weakening of resource markets is the driving cause of the lower productivity in Canada—trees remain uncut, and nature's bounty is saved to be later claimed as a "productivity dividend." Mines are shut down, and aggregate productivity appears lower. But these are primarily utilization effects, exaggerated by the fact that the industries in question are ones in which productivity is falsely claimed for output value that should be credited to the stocks of renewable and non-renewable resources.

To the extent that the value of the Canadian dollar is responsive to the prices of raw materials, which the Bank equation suggests is the case, it should be expected that GDP per capita is low in Canada when the Canadian dollar is low relative to PPP. These drops are clearly due to lower prices for resources, and not to the low value of the Canadian dollar. Indeed, the models presented at the conference suggest that the macroeconomic consequences of falling resource prices are mitigated if the Canadian dollar is able to fall by some fraction of the drop in resource prices. Thus, the results of equations based on departures from PPP cannot be used to indicate anything about the productivity effects of flexible exchanges rates for countries subject to systematic changes in their terms of trade. At the very least, it would be necessary to make use of departures of exchange rates from some fundamentals-driven value that takes the changes in resource prices directly into account.

In the meantime, to use David Longworth's attractive metaphor, it is too early to design arguments for the defense of Mr. D, since a reasonable prosecutor would find no adequate evidence at hand to justify laying charges.

Implications of the continued economic separation of nation states

In general, as I have argued elsewhere (Helliwell 2000), the fact that economic separation of nation states is much greater than is generally thought, whether measured in terms of trade, capital mobility, price linkages, or business cycle co-movements, means that the economic case for common currencies is correspondingly weaker.

Consequently, GE models, like those of Macklem et al. and Devereux, that approach reality in their separation of national goods markets, are more inclined to favour flexible over fixed exchange rates.

The models presented at this conference need to be extended to reflect another aspect of global reality: that national capital markets are also highly segmented by information, distance, and preferences, so that uncovered interest parity (UIP) cannot be assumed. In my view, the failure of UIP should be taken as given. Covered interest parity is maintained by the forward rate whipping about in response to changes in interest rates on one side or the other of the border. Consequently, we get the familiar result that the forward exchange rate is inferior to the current spot rate as a predictor of the future spot rate.

National monies and nation states: Is the correlation causal or coincidental?

The fact that there is at least a high correlation has traditionally made it difficult to assess the economic effects of common currencies, as is evident from the discussion of Rose's valuable attempts to come to grips with the issue. When the dust has settled, it will probably be found that currency effects are responsible for some fraction of the separating effects of national borders. But I suspect it will continue to be found that the net GDP effects of adopting a common currency are likely to be small and of uncertain sign. The political significance of national currencies, however, is likely to remain large. Where a supranational currency is adopted, it is likely to be done as an explicit move to cement political and economic allegiances, accompanied by the establishment of a matching supranational monetary authority. It is not easy to think of cases, beyond that of the euro, where this is likely to happen. In most other instances, common currencies are likely to arise when smaller countries adopt the more stable currency of a large neighbour or trading partner, either to gain a nominal anchor or as part of a general policy of political and economic harmonization with the larger partner.

When countries reject a common currency, as in the recent Danish vote, the matter is likely to turn on fears that the adoption of a common currency will reduce policy independence, not just in the setting of interest rates, but in other areas of social and economic policy where preferences are likely to differ from country to country. There is suggestive evidence from studies of subjective well-being, that the welfare effects of these other policies are likely to be of increasing importance relative to the direct economic consequences of exchange rate harmonization, even if the latter should turn out to be larger and more favourable to common currencies than is suggested by most of the papers in this volume. This, in turn, suggests that industrial countries capable of creating their own credible nominal anchors are unlikely to be attracted by common currencies, given the current state of the economic evidence and the fact that broader considerations favour separate national monies in the absence of an underlying desire to move towards political union.

Flexible exchange rates can only be assessed as part of a framework for monetary policy

Many participants emphasized the crucial link between monetary policy credibility and the choice of exchange rate regime. This is perhaps obvious, but it is important and often ignored. It is dangerous to have a flexible rate if there is no domestic capacity to provide monetary credibility, and there may be no reason to peg if there is such capacity. Hence, flexible exchange rates need to be considered as parts of a monetary regime, with their prospects of success so judged.

Finally, several participants noted the need for modellers and policy-makers alike to recognize that exchange rates need to be modelled, managed, and interpreted in a multilateral, not a bilateral, context. It has long been a failing of Canadian analysts and especially Canadian media, to treat the Canadian-dollar price of the U.S. dollar as though it were a sufficient description of the external value of the Canadian dollar. This leads to two sorts of error.

First, by ignoring the fact that it is just one bilateral rate, commentators are thereby encouraged to think solely of Canadian causes for movements of the rate, instead of also examining events in the partner country. This is a risk for modellers, too, as emphasized by Lipsey in his comments.

Second, judgments about whether the Canadian dollar is high or low frequently ignore all other bilateral rates, even when they are moving in the opposite direction, often by enough to make their movements the largest part of a story based on some more global or even trade-weighted view. Even as this conference was proceeding, Canadian headlines were speaking of the Canadian dollar as headed for an all-time low. Looking at the actual bilateral exchange rates told a much different and more complicated story, with changes of the Canadian dollar over the previous 12 months being +15 per cent against the euro, –2 per cent against the yen, +8 per cent against the U.K. pound, and –5 per cent against the U.S. dollar. Seen in a global context, the story is one of the strength of the U.S. dollar against the euro, with the Canadian dollar in its traditional middle ground. To avoid misleading analysis and mistaken policies, it is important that modelling and policy reactions alike be set in their appropriate multilateral context.

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General Discussion

David Laidler began by praising Michael Bordo's survey. He agreed with Bordo that monetary policy under inflation targeting is beginning to resemble the gold standard. He stressed that the credibility of inflation targets in Canada in the 1990s was underpinned by fiscal policy and, in particular, the 1995 budget was a significant event. It must be recognized that this fiscal support did not lower inflation directly, but contributed to the sustainability of low inflation with higher real growth and a vanishing output gap.

Dale Orr expressed several reservations regarding the proposition that flexible exchange rates can be advantageous in protecting against commodity price shocks. In particular, the prices of many of the commodities that Canada exports, apart from forestry products, are not strongly correlated.

Instead, the argument in favour of a flexible exchange rate should be based on protecting Canada from an external demand shock such as for automobiles, because they are our biggest export to the United States. Nonetheless, the flexible exchange rate would still have large distributional effects across regions. A decline in the U.S. demand for autos, for example, would cause a depreciation of the exchange rate and potentially a profit windfall for commodity exporters. Thus, the benefits of a flexible exchange rate must be weighed against these distributional effects.

Orr concluded by noting that the models that find greater advantages of a flexible over a fixed rate regime for Canada would also imply that British Columbia, Alberta, or Texas should have their own currencies and flexible exchange rate regimes.

Simon van Norden had two comments for Richard Lipsey. The first touched on the link between oil prices and the value of the U.S. dollar. Higher oil prices represent an adverse terms-of-trade shock to the main trading partners of the United States. Higher oil prices are very bad news for Europe, van Norden said—and even worse for Japan. The fact that we see higher oil prices leading to a real appreciation of the U.S. dollar can be interpreted as simply another link between the terms of trade and the exchange rate.

Van Norden's second comment addressed Lipsey's request for an interpretation of the Bank of Canada's exchange rate equation. He considered it useful to reinterpret the negative sign of the estimated coefficient on the energy-price variable as potentially one that is largely a U.S. story and not a Canadian one.

Robert Lafrance offered some clarification on the Bank of Canada's Amano-van Norden equation. Lafrance emphasized that the equation was not driving the Bank's view on the Canadian dollar over the medium term.

He then talked about the research of James Hamilton that implied that the U.S. economy always went into recession when there was a big oil price shock, which subsequently reduces Canada's exports. His final comment concerned the use of only Canadian variables in explaining the Canadian-U.S. dollar. He said that Ramdane Djoudad and David Tessier had carefully examined other variables, as had van Norden and Amano before them, but none of them was statistically significant.

In response to Dale Orr, John Helliwell said that he accepted the channel in the Bank's equation from the non-oil commodity prices to the exchange rate. He added that the equation provides precisely the kind of theoretical and empirical argument for the flexible exchange rate. The fact that the exchange rate responds to movements in these prices implies that terms-of-trade changes necessitate real economic adjustment.

Helliwell responded to van Norden by arguing that if Canada is a net exporter of energy products, the sign of the coefficient on the energy price variable in the exchange rate equation should be positive, i.e., higher energy prices should cause a real appreciation.

Helliwell agreed with Lafrance's statement that higher energy prices often lead to a recession in the United States, but stipulated that higher energy prices have the same effect on all countries that use energy. Similar stagflationary effects in Canada have been identified, so it isn't entirely clear that the higher prices should change the bilateral exchange rate.

Keynote Address

Canada and Flexible Exchange Rates

Milton Friedman

The last time I had an extensive talk with an official of the Bank of Canada about exchange rates was on 13 April 1948. The official was Donald Gordon, at the time the Deputy Governor. The occasion was a University of Chicago round table. The round table was a regular Sunday morning radio broadcast under the auspices of the University of Chicago. It was the most popular Sunday radio talk show. At the time, Canada was experiencing a large balance-of-payments deficit, thanks in part to having appreciated the dollar two years earlier. It was trying to defend the rate by using exchange controls, and it was having great difficulty.

That was a topic for our round table. It was broadcast from Toronto. The program itself was only half an hour but, as usual on all round table programs, the participants met the night before for dinner and a discussion in order to determine the content of the program. So I was able to have a very extensive discussion about the exchange rate problem with Donald Gordon and the other participant, Professor W.A. Mackintosh.

My impression was, hard as this may be to believe at this stage, that this was the first time that Donald Gordon had ever heard a serious defence of flexible exchange rates as a way to organize the international financial arrangements.

The next year, 1949, Canada devalued the dollar, and when that didn't work, a year later, on 30 September 1950, Canada floated the dollar. Another year later, exchange controls were dropped, and the Bank of Canada stopped intervening in the market.

By 1952, Canada was on a clean float. From 1952 to 1960, floating exchange rates worked very well; the rate didn't move around a great deal. There was short-term fluctuation but no serious crises. Speculation was clearly stabilizing. The Bank of Canada largely stayed out of it.

Why, then, did Canada go back to a pegged rate in 1962? That's a very interesting question, and I think it's very instructive experience. I discussed this question in the course of a public debate in 1967, and here is an edited version of what I said.

> . . . floating rates are not a guarantee of sensible internal monetary policy. You can have silly internal monetary policy with fixed rates, you can have silly internal monetary policy with floating rates. All floating rates do is to make it possible for you to have a sensible internal monetary policy without considering the rest of the world. . . .
>
> The reason Canada went off floating rates was because they were working so well, and their internal monetary policy was so bad.

That bad monetary policy led to high levels of unemployment and a big fight in 1961 between J.E. Coyne, Governor of the Bank of Canada at the time, and the government. The government called for his resignation. After a long argument, James Coyne finally left in mid-1961.

When he left, "there was an attempt to do something effective about the unemployment problem in Canada. But instead of correcting their bad monetary policy internally, which would have been a sensible thing to do, they [decided to] force the rate down and stimulate employment inside Canada by discouraging imports and encouraging exports"—a competitive currency devaluation, the bugbear of the 1930s.

> And so what happened? The Bank of Canada announced that it was going to try to force the price of the Canadian dollar down by exchange speculation. The speculators didn't believe it. The Bank of Canada speculated against the Canadian dollar, and the speculators absorbed the funds, and nothing happened. The Canadian rate stayed fairly fixed. So the Bank of Canada said, "We haven't been doing this on a big enough scale; we're going to do it yet." Then the Bank made bigger and bigger announcements and engaged in larger and larger speculative actions.
>
> Finally, it started the rate moving down. Once the rate started moving down, the speculators said to one another, "The government's really going to do it." So what do the speculators

> do in that case? They jump on top of the government speculation and, all of a sudden, the rate started to go down much faster than the government had intended it to go down.
>
> Now the government was stuck. "We've got a tiger by the tail," they said. "How do we stop this downward slide of the rate?" When they initially started this operation, they had no intention of pegging the rate. What they were trying to do was drive it down.
>
> When, under this stimulus, there was a rapid movement down, obviously the sensible thing for them to have done would have been to announce that they had made a mistake, that they were getting out of the market, and that they were going to let the dollar resume its former behaviour.

But, as I said then—remember I'm quoting from what I said in 1967—"no government in the world has ever done a thing like that. The key principle of a government is that you make a different mistake each time, not the same one. And you never admit that what you did before was wrong."

So, "instead of simply undoing [their mistake], they said, 'Well, the way we'll stop the rate from going down is by pegging it.' So they announced that they were going to peg it at 92.5 cents. As it happened, it took very large operations at that stage to break the speculative movement and to peg it. But they finally succeeded in pegging it at 92.5 cents. Then they were stuck with it there [until 1970]."[1]

That's the end of my quote. Now we come back to the question: Why did they float in 1970?

In 1970, expansionary policies in the United States and the international demand for Canadian goods—this was, remember, at the time of the Vietnam War—led to large surpluses in the balance of payments, which added to inflationary pressures. To counter these, the government reluctantly decided to refloat the Canadian dollar, the only major country to do so.

Then President Nixon closed the gold window on 15 August 1971. A Smithsonian agreement that was reached shortly thereafter collapsed, and floating became universal among the major countries in 1973.

Since 1970, the Canadian dollar has continued to float, with only minor intervention by the Bank of Canada. It has fluctuated widely from a trifle over one U.S. dollar to a Canadian dollar in the 1970s, to a low of around 65 cents (US) in recent years. For the most part, the short-run fluctuations have been mild, and the larger changes have occurred gradually and corresponded to the changing international position of Canada.

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[1] Quotes from Milton Friedman and Robert V. Roosa, *The Balance of Payments: Five versus Fixed Exchange Rates*, AEI Rational Debate Seminar (Washington, D.C.: American Enterprise Institute, 1967), pp. 122–25.

Over the 30 years, Canadian inflation has averaged about one-half of 1 per cent a year higher than U.S. inflation. That accounts for somewhat more than half of the decline in the Canadian dollar relative to the U.S. dollar in the past 30 years.

Canada's experience reflects very clearly the lesson that has been taught much more dramatically by the exchange crises of the 1990s. Pegged exchange rates controlled by an independent central bank are a standing invitation to balance-of-payments trouble. Every crisis in the 1990s, just as every crisis in Canada's past, was in a country with a pegged exchange rate.

Japan had very serious, and still has very serious, internal difficulties and had them all through the 1990s. But Japan has a floating exchange rate and, in consequence, it had no external balance-of-payments crises.

That raises an interesting question. Given that fact, which I think is demonstrable, why have most central banks—and here Canada is a major exception—until the last few years, been so enthusiastic about fixed, compared with floating, rates?

If a country has a truly fixed rate, the central bank has nothing to do. It simply has to let the money supply move up and down so as to maintain the exchange rate, if it's got a hard fixed rate. So you would think the central bankers wouldn't want to be put out of existence.

On the other hand, when you have a floating exchange rate, central banks serve a real function. They have to try to manage internal monetary policy in such a way that keeps the price level relatively stable, or whatever their internal objectives are. And, under those circumstances—as we can see in recent years—central bankers become important people.

I've always been puzzled by this fact, because it would seem to me that it's in the self-interest of central bankers to favour floating rates.

Questions and Answers

John Crow: Over recent years, Canada has experienced slower productivity growth than the United States. Some proponents of a fixed rate for Canada have argued that the floating rate, which has depreciated in both real and nominal terms over the 1990s, is in part responsible for this slower growth. Do you believe a floating nominal exchange rate can have an impact on productivity?

Milton Friedman: That's a very good question, a very important one. In my opinion, they are attributing to the floating rate something that is really arising from other sources. There is no reason whatsoever why a floating rate would in any way reduce your productivity. I rather think they are attributing to the floating rate what has been suggested by Michael Walker, among others, what is really attributable to your higher rates of taxation and regulation than exist in the United States and to a situation in which there is a drain of able people from Canada to the United States.

And so I suspect that if you tried to peg the rate and raise it to a higher level, you would have more trouble, not less. You would eliminate the automatic adjustments that now occur to the differences between internal conditions in Canada and internal conditions in the United States.

The point you are making is tied to why the Canadian exchange rate is depreciated relative to the United States by considerably more than can be accounted for by the difference in inflation. And that remaining difference has to be explained by differences in productivity.

In some way, it must be that Canada has had a slower rate of productivity increase than the United States has. Again, you have to ask what the cause of that is. And the cause is strictly internal. It's not going to be solved by fooling around with the exchange rate.

Charles Freedman: Recently, Ecuador and Costa Rica have dollarized. In your view, would dollarization make any sense for a country like Canada?

Milton Friedman: I think that it makes most sense for those countries who would otherwise have a very bad internal monetary policy.

My position has always been that a small country should do one of two things: eliminate its central bank and really hard peg—that is, unify its currency with the dominant currency the way Argentina has done with its currency board and Hong Kong has done with its currency board; or it ought to float completely.

Now, it makes no sense for Canada. At the moment, it seems to me that if I were a Canadian, I would not want to integrate the Canadian dollar with the U.S. dollar. U.S. monetary policy hasn't always been so good. We're in a very good patch right now, but looking over our history, Canada did much better in the 1930s than the United States did, and it did better in the 1970s, as well.

I would say that for a large country like Canada, it makes much more sense to float than it does to try to peg, to try to unify your currency with the dollar.

Lawrence Schembri: What is your opinion of the use of inflation targeting by Canada and other countries as a nominal anchor for monetary policy in conjunction with a flexible exchange rate?

Milton Friedman: It's an appropriate means. It's really a question of experience. We'll have to see how it works. So far, it seems to have been working quite well.

New Zealand, which was in some ways a pioneer in introducing inflation targeting, has been able to have a great deal of success. Britain has also inflation-targeted. On the other hand, the United States has not been an inflation-targeting country, and it also has done very well.

I think the more important fact is that all central banks have begun to learn some lessons from past experience, and they have learned to take it easy, that they shouldn't think that they are going to be able to fine-tune the economy.

The virtue of inflation targeting, in my opinion, is that it is a sort of pronouncement: we are not going to fine-tune. And that gives them some credibility in the market.

Now, my preference, of course, would be to abolish the central bank altogether and to simply have a computer that would churn out—well, I have two variants of it. In one of them, I would freeze the amount of the high-powered money and let the market go. In the other, I would assist the market by printing out a specified amount of high-powered money every month or quarter and have a steady rate of monetary growth.

In recent years, that has not looked as good as it did much earlier, because the actual relationship in the world between monetary growth and inflation in the economy has become much worse in the last 10 or 20 years. But, that's partly because there's been so much financial innovation and adaptation and, ultimately, it is the money supply that rules the roost and that will determine what long-term inflation will be.

Michael Bordo: Do you think the recent introduction of the euro will lead to the formation of other common-currency areas?

Milton Friedman: That's an extremely interesting question. I think that the euro is one of the few really new things we've had in the world in recent years. Never in history, to my knowledge, has there been a similar case in which you have a single central bank controlling politically independent countries.

The gold standard was one in which individual countries adhered to a particular commodity—gold—and they were always free to break or to leave it, or to change the rate. Under the euro, that possibility is not there. For a country to break, it really *has* to break. It has to introduce a brand new currency of its own.

I think the euro is in its honeymoon phase. I hope it succeeds, but I have very low expectations for it. I think that differences are going to accumulate among the various countries and that non-synchronous shocks are going to affect them. Right now, Ireland is a very different state; it needs a very different monetary policy from that of Spain or Italy.

On purely theoretical grounds, it's hard to believe that it's going to be a stable system for a long time. On the other hand, new things happen and new developments arise.

The one additional factor that has come out that leads me to raise a question about this is the evidence that a single currency—currency unification—tends to very sharply increase the trade among the various political units. If international trade goes up enough, it may reduce some of the harm that comes from the inability of individual countries to adjust to asynchronous shocks. But that's just a potential scenario.

You know, the various countries in the euro are not a natural currency trading group. They are not a currency area. There is very little mobility of people among the countries. They have extensive controls and regulations and rules, and so they need some kind of an adjustment mechanism to adjust to asynchronous shocks—and the floating exchange rate gave them one. They have no mechanism now.

If we look back at recent history, they've tried in the past to have rigid exchange rates, and each time it has broken down. 1992, 1993, you had the crises. Before that, Europe had the snake, and then it broke down into something else. So the verdict isn't in on the euro. It's only a year old. Give it time to develop its troubles.

Malcolm Knight: Countries with a flexible exchange rate need a nominal target for monetary policy to anchor expectations. Do you feel that inflation targeting provides a useful nominal target?

Milton Friedman: As I mentioned earlier, I think it's a good thing to have a nominal target, to say that you're not going to try to fine-tune, and to indicate what you aren't going to do. The problem I have is this: the current mechanism for all of the central banks who are inflation targeting is a short-term interest rate—as in the United States—in all of the central banks.

We know from the past that interest rates can be a very deceptive indicator of the state of affairs. A low interest rate may be a sign of an expansive monetary policy or of an earlier restrictive policy. And similarly, a high rate may be a sign of restriction, of trying to hold things down; or it may be a sign of past inflation.

The 1970s offer the classical illustration in which there were high interest rates that were reflecting the Fisher effect of inflation expectations. So I'm a little leery of operating primarily, or almost primarily, via interest rates. But, I think that having a given inflation target is a good objective. The question is, how long will you be able to keep it?

David Laidler: Many commentators are claiming that, in Japan, with short interest rates essentially at zero, monetary policy is as expansionary as it can get, but has had no stimulative effect on the economy. Do you have a view on this issue?

Milton Friedman: Yes, indeed. As far as Japan is concerned, the situation is very clear. And it's a good example. I'm glad you brought it up, because it shows how unreliable interest rates can be as an indicator of appropriate monetary policy.

The Japanese bank has supposedly had, until very recently, a zero interest rate policy. Yet that zero interest rate policy was evidence of an extremely tight monetary policy. Essentially, you had deflation. The real interest rate was positive; it was not negative. What you needed in Japan was more liquidity.

During the 1970s, you had the bubble period. Monetary growth was very high. There was a so-called speculative bubble in the stock market.

In 1989, the Bank of Japan stepped on the brakes very hard and brought money supply down to negative rates for a while. The stock market broke. The economy went into a recession, and it's been in a state of quasi-recession ever since. Monetary growth has been too low. Now, the Bank of Japan's argument is, "Oh well, we've got the interest rate down to zero; what more can we do?"

It's very simple. They can buy long-term government securities, and they can keep buying them and providing high-powered money until the high-powered money starts getting the economy in an expansion. What Japan needs is a more expansive domestic monetary policy.

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